The Effects of Water Release Strategies on Chinook Returning to the Cowichan River and the Nanaimo River

N.K. Hop Wo, D.A. Nagtegaal, and E.W. Carter

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
V9T 6N7

2005

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2715

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 1426 - 1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques ques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annual des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits a l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

105-04196/

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2715

2005

THE EFFECTS OF WATER RELEASE STRATEGIES ON CHINOOK RETURNING TO THE COWICHAN RIVER AND THE NANAIMO RIVER

by

N.K. Hop Wo, D.A. Nagtegaal, and E.W. Carter

Fisheries and Oceans Canada

Science Branch, Pacific Region

Pacific Biological Station

Nanaimo, British Columbia

V9T 6N7

© Her Majesty the Queen in Right of Canada, 2005
Cat. No. Fs 97-4/2715E ISSN 0706-6473

Correct citation for this publication:

Hop Wo, N.K., Nagtegaal, D.A., and Carter, E.W. 2005. The effects of water release strategies on Chinook returning to the Cowichan River and the Nanaimo River. Can. Manuscr. Rep. Fish. Aquat. Sci. 2715: 107 p.

TABLE OF CONTENTS

ABSTRACT XI
INTRODUCTION 1
COWICHAN RIVER 1
Water Regulation 1
NANAIMO RIVER 3
Water Regulation 4
OBJECTIVES 5
METHODOLOGY 5
STUDY AREA 5
Cowichan River 5
Nanaimo River 6
ENUMERATION FENCES 6
WATER MANAGEMENT PLANS 6
Cowichan River 7
Nanaimo River 7
RESULTS AND DISCUSSION 7
ENVIRONMENTAL, WATER RELEASE AND FENCE INFORMATION 7
Cowichan River 8
1988 8
1989 9
1990 9
1991 10
1992 11
1993 11
1994 12
1995 13
1996 13
1997 13
1998 14
1999 14

TABLE OF CONTENTS (continued)

2000 15
2001 16
2002 16
2003 17
2004 18
Nanaimo River 19
1995 19
1996 20
1997 21
1998 22
1999 22
2000 23
2001 23
2002 24
2003 24
DATA ANALYSIS 25
Cowichan River 25
Adult Chinook 26
Jack Chinook 26
Nanaimo River 26
Adult Chinook 26
Jack Chinook 26
Data Summary 26
ENVIRONMENTAL AND WATER RELEASE INFORMATION 27
Cowichan River 27
Nanaimo River 28
ADDITIONAL WATER RELEASE CONSIDERATIONS 29
2004 Cowichan River Water Release 30
ACKNOWLEDGEMENTS 31
REFERENCES 32

LIST OF TABLES

Table 1. Annual water releases and associated chinook movements, Cowichan River, 1988 - 2004 35

Table 2. Annual water releases and associated chinook movements, Nanaimo River, 1995 - 2003 37

Table 3. Daily counts and environmental information, Cowichan River enumeration fence, 1988. 38

Table 4. Daily counts and environmental information, Cowichan River enumeration fence, 1989. 39

Table 5. Daily counts and environmental information, Cowichan River enumeration fence, 1990. 40

Table 6. Daily counts and environmental information, Cowichan River enumeration fence, 1991. 42

Table 7. Daily counts and environmental information, Cowichan River enumeration fence, 1992. 44

Table 8. Daily counts and environmental information, Cowichan River enumeration fence, 1993. 46

Table 9. Daily counts and environmental information, Cowichan River enumeration fence, 1994. 48

Table 10. Daily counts and environmental information, Cowichan River enumeration fence, 1995. 51

Table 11. Daily counts and environmental information, Cowichan River enumeration fence, 1996. 52

Table 12. Daily counts and environmental information, Cowichan River enumeration fence, 1997. 54

Table 13. Daily counts and environmental information, Cowichan River enumeration fence, 1998. 55

Table 14. Daily counts and environmental information, Cowichan River enumeration fence, 1999. 56

Table 15. Daily counts and environmental information, Cowichan River enumeration fence, 2000. 58

Table 16. Daily counts and environmental information, Cowichan River enumeration fence, 2001. 60

Table 17. Daily counts and environmental information, Cowichan River enumeration fence, 2002. 61

LIST OF TABLES (continued)

Table 18. Daily counts and environmental information, Cowichan River enumeration fence, 2003. 63

Table 19. Daily counts and environmental information, Cowichan River enumeration fence, 2004. 65

Table 20. Daily counts and environmental information, Nanaimo River enumeration fence, 1995. 67

Table 21. Daily counts and environmental information, Nanaimo River enumeration fence, 1996. 69

Table 22. Daily counts and environmental information, Nanaimo River enumeration fence, 1997. 71

Table 23. Daily counts and environmental information, Nanaimo River enumeration fence, 1998. 72

Table 24. Daily counts and environmental information, Nanaimo River enumeration fence, 1999. 73

Table 25. Daily counts and environmental information, Nanaimo River enumeration fence, 2000. 74

Table 26. Daily counts and environmental information, Nanaimo River enumeration fence, 2001. 75

Table 27. Daily counts and environmental information, Nanaimo River enumeration fence, 2002. 76

Table 28. Daily counts and environmental information, Nanaimo River enumeration fence, 2003. 78

LIST OF FIGURES

Figure 1. Cowichan River Watershed study area. 79
Figure 2. Nanaimo River Watershed study area. 80
Figure 3. Monthly Cowichan River discharge (m^3/s) in 1988 along with period mean. 81
Figure 4. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1988. 81
Figure 5. Monthly Cowichan River discharge (m^3/s) in 1989 along with period mean. 82
Figure 6. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1989. 82
Figure 7. Monthly Cowichan River discharge (m^3/s) in 1990 along with period mean. 83
Figure 8. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1990. 83
Figure 9. Monthly Cowichan River discharge (m^3/s) in 1991 along with period mean. 84
Figure 10. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1991. 84
Figure 11. Monthly Cowichan River discharge (m^3/s) in 1992 along with period mean. 85
Figure 12. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1992. 85
Figure 13. Monthly Cowichan River discharge (m^3/s) in 1993 along with period mean. 86
Figure 14. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1993. 86
Figure 15. Monthly Cowichan River discharge (m^3/s) in 1994 along with period mean. 87
Figure 16. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1994. 87
Figure 17. Monthly Cowichan River discharge (m^3/s) in 1995 along with period mean. 88
Figure 18. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1995. 88

LIST OF FIGURES (continued)

Figure 19. Monthly Cowichan River discharge (m^3/s) in 1996 along with period mean. 89

Figure 20. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1996. 89

Figure 21. Monthly Cowichan River discharge (m^3/s) in 1997 along with period mean. 90

Figure 22. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1997. 90

Figure 23. Monthly Cowichan River discharge (m^3/s) in 1998 along with period mean. 91

Figure 24. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1998. 91

Figure 25. Monthly Cowichan River discharge (m^3/s) in 1999 along with period mean. 92

Figure 26. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1999. 92

Figure 27. Monthly Cowichan River discharge (m^3/s) in 2000 along with period mean. 93

Figure 28. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 2000. 93

Figure 29. Monthly Cowichan River discharge (m^3/s) in 2001 along with period mean. 94

Figure 30. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 2001. 94

Figure 31. Monthly Cowichan River discharge (m^3/s) in 2002 along with period mean. 95

Figure 32. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 2002. 95

Figure 33. Monthly Cowichan River discharge (m^3/s) in 2003 along with period mean. 96

Figure 34. Daily river depth (crn) and chinook counts, Cowichan River, 2003. 96

Figure 35. Monthly Cowichan River discharge (m^3/s) in 2004 along with period mean. 97

LIST OF FIGURES (continued)

Figure 36. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 2004 97

Figure 37. Monthly Nanaimo River discharge (m^3/s) in 1995 along with period mean 98

Figure 38. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1995 98

Figure 39. Monthly Nanaimo River discharge (m^3/s) in 1996 along with period mean 99

Figure 40. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1996 99

Figure 41. Monthly Nanaimo River discharge (m^3/s) in 1997 along with period mean 100

Figure 42. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1997 100

Figure 43. Monthly Nanaimo River discharge (m^3/s) in 1998 along with period mean 101

Figure 44. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1998 101

Figure 45. Monthly Nanaimo River discharge (m^3/s) in 1999 along with period mean 102

Figure 46. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1999 102

Figure 47. Monthly Nanaimo River discharge (m^3/s) in 2000 along with period mean 103

Figure 48. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 2000 103

Figure 49. Monthly Nanaimo River discharge (m^3/s) in 2001 along with period mean 104

Figure 50. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 2001 104

Figure 51. Monthly Nanaimo River discharge (m^3/s) in 2002 along with period mean 105

Figure 52. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 2002 105

LIST OF FIGURES (continued)

Figure 53. Monthly Nanaimo River discharge (m^3/s) in 2003 along with period mean. 106

Figure 54. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 2003. 106

Figure 55. Mean total counts by time interval at the Cowichan River (2000-2004) and Nanaimo River (2000-2003) enumeration fences. 107

ABSTRACT

Hop Wo, N.K., Nagtegaal, D.A., and Carter, E.W. 2005. The effects of water release strategies on Chinook returning to the Cowichan River and the Nanaimo River. Can. Manuscr. Rep. Fish. Aquat. Sci. 2715: 107 p.

Fisheries and Oceans Canada (DFO) in conjunction with Cowichan Tribes and Snuneymuxw First Nation operated enumeration fences in the Cowichan River (1988-2004) and in the Nanaimo River (1995-2003). Annually negotiated water management plans generally make provisions for a pulse water release, designed to aid chinook salmon in their migration to the spawning grounds.

DFO in conjunction with NorskeCanada, Land and Water British Columbia, Cowichan River Hatchery, and Cowichan Tribes annually negotiate a water management plan for the Cowichan River Watershed. The Wilcoxon paired-sample test (n=18) supports the assumption that significantly more fish migrate past the fence site during a release period when compared to a period prior to the release. While a 24-hour water release can be effective in moving fish upstream, the recommended minimum length of a water release is 48 hours. The recommended minimum discharge to be released at the Cowichan Lake Weir is 16.1 m^3/s (569 ft^3/s). In 2004, additional flows allowed the testing of the maximum discharge the enumeration fence can safely maintain while in operation. The maximum flow the fence can sustain is 22.65 m^3/s (800 ft^3/s).

Similarly, DFO in conjunction with Land and Water British Columbia, Greater Nanaimo Water District, City of Nanaimo, Pope and Talbot Limited, and Snuneymuxw First Nation negotiate an annual water management plan for the Nanaimo River Watershed. The Wilcoxon pair-sample test (n=9) supports the assumption that significantly more fish migrate past the fence site during a release period when compared to a period prior to the release. The minimum recommended length of a water release is 48 hours while the optimum length is three to four days. The recommended minimum discharge for a water release is 14.87 m^3/s (525 ft^3/s), to be released from Fourth Lake.

This report summarizes previous chinook enumerations and water release data to provide recommendations for future release strategies.

RÉSUMÉ

Hop Wo, N.K., Nagtegaal, D.A., and Carter, E.W. 2005. The effects of water release strategies on Chinook returning to the Cowichan River and the Nanaimo River. Can. Manuscr. Rep. Fish. Aquat. Sci. 2715: 107 p.

Pêches et Océans Canada (MPO), conjointement avec les tribus Cowichan et la Première nation Snuneymuxw, ont tenu des barrières de dénombrement érigées dans la rivière Cowichan et dans la rivière Nanaimo de 1988 à 2004 et de 1995 à 2003 respectivement. Les plans de gestion des eaux négociés annuellement prévoient généralement un apport d'eau ponctuel, visant à favoriser la migration du saumon quinnat vers ses frayères.

Le MPO, conjointement avec NorskeCanada, Land and Water British Columbia, les exploitants de l'écloserie de la rivière Cowichan et les tribus Cowichan, négocient chaque année un plan de gestion des eaux pour le bassin hydrographique de la rivière Cowichan. Le test de Wilcoxon pour observations appariées (n = 18) étaye l'hypothèse à l'effet qu'un nombre significativement plus élevé de saumons franchissent la barrière durant une période d'apport d'eau en comparaison de la période précédant cet apport. Bien qu'un apport d'eau pendant 24 heures peut être efficace pour ce qui est d'aider les saumons à remonter vers les eaux d'amont, la durée minimale recommandée d'un apport d'eau est de 48 heures. Le débit minimum recommandé à la barrière du lac Cowichan est de 16,1 m^3/s (569 pi^3/s). En 2004, des apports additionnels ont permis d'établir que la barrière de dénombrement pouvait soutenir sans danger un débit maximum de 22,65 m^3/s (800 pi^3/s).

De même, le MPO, conjointement avec le Greater Nanaimo Water District de Land and Water British Columbia, la ville de Nanaimo, Pope and Talbot Limited et la Première nation Snuneymuxw négocient chaque année un plan de gestion des eaux pour le bassin hydrographique de la rivière Nanaimo. Le test de Wilcoxon pour observations appariées (n = 9) étaye l'hypothèse à l'effet qu'un nombre significativement plus élevé de saumons franchissent la barrière durant une période d'apport d'eau en comparaison de la période précédant cet apport. La durée minimale recommandée d'un apport d'eau est de 48 heures, alors que la durée optimale est de trois à quatre jours. Le débit minimum recommandé pour un apport d'eau, en provenance du lac Fourth, est de 14,87 m^3/s (525 pi^3/s).

Le présent rapport est un résumé des dénombrements antérieurs de saumon quinnat et des données antérieures sur les apports d'eau ponctuels qui ont servi à la formulation de recommandations en matière de stratégies futures d'apport d'eau.

INTRODUCTION

The Cowichan and Nanaimo River watersheds have been experiencing increased drought conditions in the 2003 – 2005 period which created a community of interest to share scarce water supplies. This was especially evident in 2004, within the Cowichan River Watershed, when a dry summer left few options for in-stream water flows and licensed industrial water which threatened closure of the Crofton Pulp Mill should storage supplies become exhausted. As drier summers and competition for water resources increase, new water management strategies will be crucial in alleviating potential water shortfalls. This report will explore and evaluate previous water release strategies employed within the Cowichan and Nanaimo River systems.

COWICHAN RIVER

The Cowichan River hosts "ocean type" chinook which enter the river in late August to the middle of November (Healey, 1991). Lister et al. (1971) notes that most fry reach the estuary within three months of emergence and are known as the 'early group'. A second group of fry, approximately 15% of total juvenile population, are know as the 'late group' and spend up to an additional 90 days rearing within the freshwater environment.

In 1989, Fisheries and Oceans Canada established an enumeration fence upstream of the City of Duncan. This fence is of a floating design and is installed and removed annually. Major hatchery production of chinook on the Cowichan River began in 1980 (Cross et al. 1991). Chinook fry releases have increased from 64,681 in 1980 to 3.23 million fry in 2002 (Nagtegaal et al. 2004).

Water Regulation

In 1956, a one metre low head seasonally operated weir was constructed at the outlet of Cowichan Lake to store the mill's water requirements during low flow summer fall period. The weir is generally left open from the months of November to March, with regulation required during the drier months of April to October. During the summer months, flow is maintained well above the natural flow regime at 7.08 m^3/s (250 ft^3/s). This flow level is considered optimal for rearing and is an improvement over natural regime. These improved minimum flows assist returning chinook (Burt and Robert 2002). Water regulation at the weir follows a rule curve established by Land Water BC Inc and is managed by the NorkseCanada Pulp Mill. The 1950's water license supports a water management regime providing summer flow below the weir at almost double the historic average measured above the mill's intake, and equal to the historic average below the intake. This water storage and management regime was

agreed to by Fisheries and Oceans Canada (DFO) and was licensed by the Province as a water licence in support of the Crofton Pulp Mill. The intake for the water supply and the NorskeCanada Crofton Mill is located ten kilometres upstream of the estuary. Since that time, seasonally stored water in Cowichan Lake has been released at the weir into Cowichan River and withdrawn downstream near the City of Duncan, and pumped by pipeline to the Crofton Pulp Mill.

In the mid-80's low water flow conditions in the fall were experienced for several consecutive years. In addition, DFO Fishery Officers (T. Fields, 60 Front St., Nanaimo, B.C., V9R 5H7, pers comm.) observed that these conditions had potentially significant negative impacts on the upstream migration and subsequent spawning success of chinook salmon. Negative impacts included increased susceptibility to poaching and predation as well as increased stress levels for chinook holding in the estuary and lower river while waiting for sufficient flows. In 1987, was a wet year and spring runoff was stored and several experimental pulse flows were tried to assist chinook migration. These pulse flows have become an annual strategy whenever sufficient storage was possible. The increased pulse flows would allow chinook to move from warmer, less protected lower reaches into the cooler and more protected waters of the middle river sections. Based on these considerations, the desire to create a process that would allow for active management of water flows on the Cowichan was initiated. Within the framework of the existing water license agreements with the Crofton Pulp Mill, the Provincial Water Management Branch in conjunction with DFO Habitat and local stakeholders began to develop a round table to discuss annual water management strategy that would help mitigate the problems associated with persistent low flows late into the fall months.

The weir at the outlet of Cowichan Lake is seasonally managed by NorskeCanada in conjunction with their water licence under regulatory of Land Water BC Inc. The weir controls the storage and water discharged into the river so that a prescribed water supply is available to the Cowichan R. and for the NorskeCanada Mill in Crofton. The weir can control water flow only up to a certain sill height, above which water flows freely over the weir and over the control gates.

In the past 50 years, the water flow was managed to a provisional rule curve. The possibility existed to make some minor adjustments to this provisional rule curve which would benefit the fisheries resource. It was suggested that a pulse flow of approximately 14.16 – 19.82 m^3/s be released at the appropriate time. Criteria used to determine timing of the water release included observations regarding the numbers of chinook holding in the Cowichan estuary, environmental conditions, and appropriate tide schedules relative to peak chinook upstream migration times.

available storage. Flows would be regulated from Cowichan Lake in May/June and if storage was available for release in late September to aid chinook migration, a round table decision was made. The goal was to increase chinook escapement when significant numbers of chinook were observed holding in the estuary and lower reaches then releasing a pulse flow, thereby aiding their upstream migration to the spawning grounds.

In the late 1980's, chinook escapements were low and surplus spring runoff in Cowichan Lake was used to release experimental fall pulse flows in an attempt to assist adult chinook migration. Migration behaviour was assessed by means of the Cowichan Adult Salmon Counting Fence Program. Fall pulse flows proved to be a very effective technique for stimulating adult chinook migration from the estuary to their upper Cowichan spawning grounds. Since then, this practice has been employed whenever Cowichan Lake storage is available.

In the early 1990's, DFO and provincial Fisheries contracted KPA Engineering to study historic water flow data and model criteria for an improved Cowichan River water conservation strategy. The primary recommendation resulting from that study was to reduce the risk of low seasonal flows by increasing Cowichan Lake storage by raising the existing 1.0 m. high weir by an additional 0.57m. This modification would address the following objectives:

1. Maintain minimum spring/summer/fall flows.
2. Provide chinook pulse flows in the fall.

Further development of this plan was suspended due to concerns about elevated summer water levels by Cowichan Lake property owners. Nonetheless, a Cowichan-Koksilah Water Management Plan (1986) which had been prepared by the provincial water agency made 23 recommendations, one of which recommended that further investigation and inventory be done of potential storage sites for all streams in the watershed having present or projected water shortages. In 2005, all agencies and water users agreed that a long term Cowichan Basin Water Management Plan was necessary to evaluate current status, and what water management objectives and priorities should be the focus of the Cowichan Valley.

NANAIMO RIVER

The Nanaimo River system is unique in that it has three distinct populations of chinook. Two spring run chinook stocks enter the watershed between December and May and hold in First Lake, Second Lake, or deep river pools before spawning in late summer or early fall (Blackman 1981, Brahniuk et al. 1993, Nagtegaal and Carter 2000b). The two spring stocks differ in spawning locations as well as fry out-migration timing. One group spawns between the First Lake and Wolfe Creek area and produces ocean-type fry which rear for up

to 90 days in freshwater before heading to the estuary. The second spring run stock spawns upstream of Second Lake to Fourth Lake and produces stream-type fry which can spend up to one year in freshwater before out-migrating. The third distinct chinook stock, the fall run, is the predominant group which enters the river between late August and the middle of November and spawns below First Lake (Carter et al. 2004). It is the fall run stock which will be the focus of this study.

Escapement estimates for the Nanaimo River fall run chinook were based on information from Fisheries Officers through the use of aerial overflights and stream walks. In 1995, in order to improve escapement estimate accuracy, DFO in conjunction with Snuneymuxw First Nation installed and operated an enumeration fence (Carter and Nagtegaal 1997).

Water Regulation

There are three dams regulating flows within the Nanaimo River watershed. The first dam was constructed in 1931 on the South Nanaimo River to store water for the City of Nanaimo. It is over 30 metres in height and has a capacity to store 2.05 million cubic metres of water. During high flows, water is able to spill over the top of the dam and during low flows 0.57 m^3/s (20 ft^3/s) of leakage is available to the Nanaimo River. A second dam was created in 1954 at the outlet of Fourth Lake to provide water to operate the Harmac Pacific pulp mill in Nanaimo. This dam has the capacity to hold back 34.5 million cubic metres of water and has a required discharge rate of 1.1 m^3/s (39 ft^3/s) into the Nanaimo River Watershed. The cold water release from the Fourth Lake Dam is discharge from a valved pipe 80 feet below the top of the dam. A third dam was erected in 1974 at Jump Lake in order to further increase the water storage capacity for the City of Nanaimo's reservoir up to 12.3 million cubic metres. Water released from Jump Lake is discharged 60 feet below the top of the dam. Adding flood gates to the dam in 1987 allowed for an increase capacity of 16.0 million cubic metres. The City is examining further storage options in 2005

Between 1954 and 1989, fall water releases into the Nanaimo River were informal requests made by local Fishery Officers and were dependant on water reserves carried out by MacMillan and Bloedel's Harmac Mill. In 1989, after successes in the Cowichan, co-ordinated pulse releases from Jump Creek Reservoir and Fourth Lake of approximately 10 m^3/s (353 ft^3/s) and 11.3 m^3/s (399 ft^3/s) were conducted and arranged by the Regional Water Manager (Carter and Nagtegaal 1997). During this period, a Nanaimo Basin Water Management Plan was developed to integrate the water licencees and the in-river flow requirements. Since that time, the continuation of water pulse flows has aided in the up-migration of fall chinook in periods of low water which typically occurs in late September and early October.

OBJECTIVES

This report presents the results of fall run chinook enumeration and water release strategies on the Cowichan River and Nanaimo River during 1988-2004 and 1995-2003 seasons, respectively. The objectives include:

1. Enumerating adult and jack chinook salmon migrating past the fence during scheduled water releases.

2. Assessing the impact of water releases on aiding the upstream migration of chinook salmon past the enumeration fence.

3. Creating recommendations on ramping of water releases, peak discharge rates, and length of releases which will both optimize upstream migration of salmon and conserve water for other user groups.

METHODOLOGY

STUDY AREA

Cowichan River

The Cowichan River flows through the City of Duncan on the East coast of Vancouver Island before draining into the Strait of Georgia. Five lakes and 26 tributaries drain into the Cowichan River totalling 826 km^2, with the largest lake being Cowichan Lake and the largest tributary being the Koksilah River (Figure 1) (Nagtegaal et al. 2004). A weir at the outlet of Cowichan Lake controls water discharge into the Cowichan River. The Cowichan watershed is host to all five Pacific salmon species (*Oncorhynchus nerka, O. tshawytscha, O. keta, O. gorbuscha, and O. kisutch*) as well as steelhead trout (*O. mykiss*), brown trout (*Salmo trutta*), cutthroat trout (*O. clarki*), kokanee salmon (*O. nerka*), dolly varden char (*Salvelinus malma*), and brook trout (*S. fontinalis*) (Nagtegaal et al. 2004). The Cowichan River enumeration fence is located at the old City of Duncan pumphouse, approximately ten kilometres upstream of the estuary (Nagtegaal et al. 1994a).

Nanaimo River

The Nanaimo River is located on the East coast of Vancouver Island and runs into the Strait of Georgia at the South end of the City of Nanaimo. The Nanaimo River watershed is approximately 830 km^2 in area and is fed primarily by four lakes, with the largest lakes being First and Second Lake (Nagtegaal and Carter 2000b). Three dams regulate flows into the Nanaimo River, they are located on the South Nanaimo River, Fourth Lake, and Jump Lake (Figure 2). The Nanaimo River watershed hosts four Pacific salmon species (*O. tshawytscha, O. keta, O. gorbuscha, and O. kisutch*) as well as cutthroat (*O. clarki*) and rainbow trout (*O. mykiss*). The Nanaimo River enumeration fence is located 200 metres upstream of the Cedar Bridge in South Nanaimo (Figure 2) (Carter et al. 2004).

ENUMERATION FENCES

Enumeration fences are of a floating weir design and stretch across the river guiding fish through an opening where they are counted. Both fences are of similar design being made of PVC piping held together with aluminium cross-members, creating approximately 25 – 30 panels. The fence panels are secured to the substrate via airline cables fed through aluminium "T's" attached to a steel track located on the river bottom. The top side of the fence panels floats on a resistance-board fitted with styrofoam to increase fence buoyancy.

In order for fish to travel past the fence they must swim through a trap box area where they are enumerated before continuing their upstream migration. The trap box is located underneath an observation tower where one or two individuals will identify the species; determine whether the fish is a juvenile, jack, or adult; and enumerate the fish. A white flashboard is fastened beneath the trap box to aid visibility and markers attached to the flashboard help identify between jack and adult salmon. During night hours, flood lights are directed into the trap box to allow nocturnal fish migrations to be enumerated.

WATER MANAGEMENT PLANS

Both Cowichan River and Nanaimo River water management plans incorporate the ramping of water levels to minimize effects of sudden changes in river dynamics. Possible effects include the stranding of fish, alteration of river hydrology, and erosion of river banks.

Cowichan River

Low river flows combined with increased demand for water consumption have resulted in an annual water management plan for the Cowichan River Watershed. Water levels are controlled by NorskeCanada via a weir at the outlet of Cowichan Lake. Annual discussions between NorskeCanada, Fisheries and Oceans Canada, Land and Water British Columbia, Cowichan River Hatchery, Cowichan Tribes, and other user groups result in a water management plan for the Cowichan River Watershed. Goals for the management plan include water releases to encourage salmon to migrate upstream while maintaining sufficient river levels for industrial, First Nations, and recreational users (Nagtegaal et al. 2004). All river discharge rate measurements referring to the Cowichan River were obtained from Water Survey Canada Station 08HA011 which is located near the Island Highway Bridge in Duncan, British Columbia.

Nanaimo River

In 1989, the B.C. Ministry of Environment (BCMOE) initiated the first water management plan for the Nanaimo River Watershed. There are currently several interest groups participating in negotiating an annual water management plan. This management team consists of BCMOE, Greater Nanaimo Water District, City of Nanaimo, Pope and Talbot Limited, Snuneymuxw First Nation, and Fisheries and Oceans Canada. The management plan is designed to enhance flows and meet the requirements of returning salmon while maintaining adequate flows for industrial and municipal needs. This is of greatest concern during September and October in a ten kilometre section of river below the water intake for Harmac Pacific (Carter et al. 2004). All river discharge rate measurements referring to the Nanaimo River were obtained from Water Survey Canada Station 08HB034 which is located upstream of the "Bungy Zone" in Cassidy, British Columbia.

RESULTS AND DISCUSSION

ENVIRONMENTAL, WATER RELEASE AND FENCE INFORMATION

Environmental information collected includes temperature, visibility, and relative river depth at the fence site.

Discharge data for the Cowichan River were obtained by Water Survey of Canada at Station 08HA011 near the Island Highway Bridge in Duncan, British Columbia (Water Survey of Canada 2004). Discharge data referring to a target release rate are measured directly at the Cowichan Lake Weir. This information is collected through Water Survey of Canada Station 0HA002. Please note that

Figures 3 – 33 show comparisons with 1988 – 2003 discharge means and do not include 2004 data as they are preliminary and still subject to revision.

Discharge information for the Nanaimo River was obtained by Water Survey of Canada at Station 08HB034, near Cassidy, British Columbia (Water Survey of Canada 2004).

Notes pertaining to daily fence enumeration information for specific rivers and years are made below, (Tables 3 – 19 for Cowichan River and Tables 20 – 28 for Nanaimo River).

Cowichan River

Cowichan Lake, at 62 km^2, is the single largest contributor of water to the Cowichan River. The large surface area of the lake allows for the surface water to become warmer than the subsurface water, especially in hot summer months. As the weir at the outlet of Cowichan Lake allows surface water to spill out of the lake, this water would be warmer than if the water was drawn from the bottom of the lake. The released water takes approximately 12 hours to reach the fence site where a resulting increase in depth can be measured. A summary of all water releases and associated chinook movements at the Cowichan River enumeration fence is presented in Table 1.

1988

This was the first year an extensive in-river survey of the Cowichan River was conducted. The fence was constructed mainly of seine netting strung across the river which encouraged fish to swim through a counting channel (Nagtegaal et al. 1994c).

During 1988, discharge rates were below the average for January, February, and March, but above for April. During May to November, the discharge rates were close to the period average (Figure 3). During the enumeration period, daily mean fence depth ranged from 48.0 cm to 85.0 cm and averaged 67.2 cm while water temperature ranged from 10.0°C to 16.0°C and averaged 13.7°C (Table 3).

During the spring of 1988, water was conserved for a water release later in the fall. A single water release occurred between 24 and 27 September. River discharge increased from 5.39 m^3/s (190 ft^3/s) on 24 September to 11.0 m^3/s on the following day. During the release, fence depth increased from 53 cm on 24 September to 79 cm on 26 September; water temperature remained a constant 14°C. Rainfall was recorded during the time of release and an increase in the number of chinook was noted. Between 25 September and 05 October, 2,869

adult chinook and 2,595 jack chinook migrated past the fence site (55.56% and 61.15% of fence enumeration, respectively) (Nagtegaal et al. 1994c). Daily adult and jack chinook fence counts as well as discharge rates for 1988 are displayed in Figure 4.

1989

During 1989, the enumeration fence was in operation from 13 September to 24 October when the fence was "washed out" due to high flows. The seine net fence was of the same design as the previous year (Nagtegaal et al. 1994c).

During 1989, discharge rates were below the average for January and February. Discharge rates for the remaining months were close to the period mean (Figure 5). During the enumeration period, daily mean fence depth ranged from 35.0 cm to 79.0 cm and averaged 43.5 cm while water temperature ranged from 11.0°C to 17.0°C and averaged 14.1°C (Table 4).

In 1989, difficulties in negotiating a water release strategy resulted in less water than was anticipated. A two day water release occurred during 01 and 02 October when river discharge increased from 5.4 m^3/s to 8.3 m^3/s. During the release, fence depth increased from 48 cm on 01 October to 50 cm on the following day; water temperature decreased from 15°C to 14°C. No Rainfall occurred during the release and chinook movement was minimal. During 02 October, 104 adult chinook and 87 jack chinook migrated past the fence (7.85% and 8.51% of fence enumeration, respectively) (Nagtegaal et al. 1994c). Daily adult and jack chinook fence counts as well as discharge rates for 1989 are displayed in Figure 6.

1990

During 1990, the enumeration fence was in operation from 12 September to 25 October. A new fence design incorporated a resistance-board weir design which self-adjusted to changing river flows. This new floating fence encouraged large debris to flow overtop of the fence, thereby, reducing maintenance time and physical stress on the fence (Nagtegaal et al. 1994a).

During 1990, discharge rates were close to the period mean in all months except for November and December when rates were higher (Figure 7). During the enumeration period, daily mean fence depth ranged from 11.5 cm to 42.6 cm and averaged 26.8 cm while water temperature ranged from 11.0°C to 19.0°C and averaged 15.5°C (Table 5).

In 1990, two water releases took place. The first release occurred between 22 and 26 September where river discharge increased from 7.29 m^3/s

on 22 September to 15.80 m^3/s on 23 September. Fence depth increased from 12.5 cm on 22 October to 30.9 cm on 23 October; water temperature increased from 17°C on 22 October to 19°C on 24 October. During the release, clear and sunny weather was noted and 1,282 adult chinook and 5,421 jack chinook migrated past the fence (30.79% and 35.67% of fence enumeration, respectively).

The second release commenced on 03 October and was combined with rain. This resulted in river discharge increasing from 8.38 m^3/s to 19.10 m^3/s on the following day. Fence depth increased from 17.5 cm on 03 October to 38.6 cm on 05 October; water temperature fluctuated between 14°C and 16°C. Chinook movement during the release was greatest between 04 October and 08 October when 1,627 adult chinook and 3,191 jack chinook migrated past the fence (39.07% and 20.99% of fence enumeration, respectively) (Nagtegaal et al. 1994a). Daily adult and jack chinook fence counts as well as discharge rates for 1990 are displayed in Figure 8.

1991

During 1991, the enumeration fence was in operation from 19 August to 11 November. The same fence design as the previous year was used with the exception of the panel length which was increased from 3.6 metres to 6.0 metres. Between 31 August and 09 September no fence counts were made due to extremely high water (Nagtegaal et al. 1994a).

During 1991, discharge rates were slightly below the period mean for January, March to July, and October to December. In February, the monthly mean was approximately 50 m^3/s higher than average while in September, the mean was 23.5 m^3/s or almost four times the period average (Figure 9). During the enumeration period, daily mean fence depth ranged from 36.2 cm to 91.0 cm and averaged 53.1 cm while water temperature ranged from 10.0°C to 23.0°C and averaged 15.2°C (Table 6).

In 1991, the water release occurred between 04 and 09 October when river discharge increased from 12.40 m^3/s on 04 October to 20.2 m^3/s the following day. Fence depth increased from 51.5 cm on 04 October to 62.8 cm on 08 October. During the release period, water temperature fluctuated from 15°C to 16°C and weather conditions were clear and sunny before and during the release. The 1991 enumeration had unusually high water preceding the water release with the month of September having a mean discharge four times greater than the 1988-2003 average. Salmon migration during the release was less distinct than in previous years; consequently, salmon migration during the release was less distinct than in previous years, with a one day increase of 265 adult chinook and 142 jack chinook on 08 October (11.16% and 8.73% of fence

enumeration, respectively) (Nagtegaal et al. 1994a). Daily adult and jack chinook fence counts as well as discharge rates for 1991 are displayed in Figure 10.

1992

In 1992, the enumeration fence was in operation from 18 August to 31 October with the same fence design as the previous year (Nagtegaal et al. 1994b).

During 1992, mean monthly discharge was higher than the period average in January and February. The monthly discharge rates were lower than expected in March to June and October to December (Figure 11). During the enumeration period, daily mean fence depth ranged from 13.7 cm to 56.5 cm and averaged 27.5 cm while water temperature ranged from 8.0°C to 22.0°C and averaged 15.3°C (Table 7).

In 1992, the water release occurred on 27 September at 12:00 pm and finished on 05 October. Discharge increased from 7.6 m^3/s on 27 September to a peak of 12.5 m^3/s on 03 October. Fence depth increased from 22.1 cm on 27 October to 35.7 cm on 02 October; water temperature fluctuated between 13°C and 18°C. Clear and sunny weather conditions were noted before and during the scheduled water release. Fish movement was greatest between 28 September and 05 October when 1,123 adult chinook and 146 jack chinook migrated past the fence (14.51% and 3.95% of fence enumeration) (Nagtegaal et al. 1994b). Daily adult and jack chinook fence counts as well as discharge rates for 1992 are displayed in Figure 12.

1993

In 1993, the enumeration fence was in operation from 23 August to 22 November with the same fence design as the previous year (Nagtegaal et al. 1995a).

During 1993, mean monthly discharge was lower than the period average between January and March and in October and November. The monthly discharge rates for the remaining months were similar to past years (Figure 13). During the enumeration period, daily mean fence depth ranged from 21.1 cm to 43.0 cm and averaged 30.3 cm while water temperature ranged from 7.0°C to 19.0°C and averaged 13.9°C (Table 8).

In 1993, the water release occurred on 26 September at 12:00 pm and finished on 30 September. Discharge increased from 5.49 m^3/s on 25 September to 14.6 m^3/s on 27 September. Fence depth increased from 25.7 cm on 26 September to 42.3 cm on 28 September; water temperature rose 2°C from 14°C

on 26 September to 16°C on 29 September. Clear and sunny weather conditions were noted prior to and during the water release. Fish movement was less distinct than previous years with 237 adult chinook and 540 jack chinook migrating past the fence site during the release period (4.69% and 9.36% of fence enumeration, respectively). The peak movement occurred on 27 September when 105 adult chinook and 484 jack chinook were counted (2.08% and 8.39% of fence enumeration, respectively) (Nagtegaal et al. 1995a). Daily adult and jack chinook fence counts as well as discharge rates for 1993 are displayed in Figure 14.

1994

In 1994, the enumeration fence was in operation from 15 August to 13 November with the same fence design as the previous year. Between 31 October and 13 November the fence was partially submerged but remained in operation and fully functional (Nagtegaal et al. 1995b).

During 1994, mean monthly discharge was lower than the period average in January and February and in October and November. The monthly discharge rates for the remaining months was similar to past years except for March which had a discharge 74% higher then expected (Figure 15). During the enumeration period, daily mean fence depth ranged from 14.5 cm to 92.2 cm and averaged 29.0 cm while water temperature ranged from 9.0°C to 20.0°C and averaged 14.7°C (Table 9).

In 1994, there was enough stored water to allow for two releases. The first release occurred on 05 October at 08:00 hours and was maintained for 72 hours with a target discharge rate of 20 m^3/s. River discharge, measured at the Island Highway Bridge in Duncan, increased from 5.23 m^3/s on 04 October to 13.2 m^3/s on 06 October. Fence depth increased from 19.6 cm on 05 October to 28.7 cm on 06 October; water temperature maintained a constant 14°C. Fish movement was greatest between 06 October and 07 October where 1,853 adult chinook and 4,560 jack chinook past the fence site (36.69% and 34.08% of fence enumeration, respectively) (Nagtegaal et al. 1995b).

The second water release commenced on 17 October at 08:00 hours and was maintained for 72 hours with a target discharge rate of 13 m^3/s. River discharge, measured at the Island Highway Bridge in Duncan, increased from 5.16 m^3/s on 16 October to 11.9 m^3/s on 18 October. Fence depth increased from 19.2 cm on 17 October to 29.2 on 20 October; water temperature maintained a constant 11°C. Fish movement during the release period peaked on 18 October when 292 adult chinook and 330 jack chinook migrated past the fence site (5.78% and 2.47% of fence enumeration, respectively) (Nagtegaal et al. 1995b). Daily adult and jack chinook fence counts as well as discharge rates for 1994 are displayed in Figure 16.

1995

In 1995, the enumeration fence was in operation from 08 September to 19 October with the same fence design as the previous year (Nagtegaal et al. 1996).

During 1995, mean monthly discharge was higher than the period average between January to March and in November and December. The monthly discharge rates were lower than expected for May, June, and July (41.5%, 29.5%, 57.3% of period average, respectively) (Figure 17). During the enumeration period, daily mean fence depth ranged from 30.0 cm to 74.8 cm and averaged 45.7 cm while water temperature ranged from 12.0°C to 20.0°C and averaged 16.0°C (Table 10).

In 1995, due to low reservoir levels, only a 24-hour water release was available to aid in fish migration. This release commenced at 08:00 hours on 22 September. The target release rate was 7.1 m^3/s, with the river discharge rate increasing from 5.79 m^3/s on 21 September to 7.09 m^3/s on 23 September. Depth at the fence site increased from 42.7 cm on 21 September to 46.5 cm on the night shift of 22 September; water temperature dropped from 19°C on 21 September to 16°C on 23 September. The weather before and during the release was noted as being warm and dry. The water release appeared to have little or no effect on fish movement with 129 adult chinook and 209 jack chinook migrating past the fence site (1.20% and 2.64% of fence enumeration, respectively) (Nagtegaal et al. 1996). Daily adult and jack chinook fence counts as well as discharge rates for 1995 are displayed in Figure 18.

1996

In 1996, the enumeration fence was in operation from 30 August to 24 October with the same fence design as the previous year (Nagtegaal and Carter 1998a) (Table 11). Monthly discharge rates as well as daily discharge rates with chinook counts are displayed in Figure 19 and Figure 20.

In 1996, no scheduled water release occurred.

1997

In 1997, the enumeration fence was in operation from 05 September to 03 October with the same fence design as the previous year. The fence was removed earlier then expected due to heavy rains resulting in high water flows (Nagtegaal and Carter 1998b).

During 1997, mean monthly discharge was higher than the period average in January and between March to November. The monthly discharge rates were

similar to the period mean in February and December (Figure 21). During the enumeration period, daily mean fence depth ranged from 29.0 cm to 128.0 cm and averaged 56.2 cm while water temperature ranged from14.5°C to 19.0°C and averaged 16.5°C (Table 12).

In 1997, a two-stage water release occurred between 17 and 29 September. The first portion of the release commenced on 17 September when the release rate from the weir outflow was increased from 8.4 m^3/s to 28.3 m^3/s at 08:00 hours. Outflow was further increased on 25 September from 26.9 m^3/s to 33.6 m^3/s with the pulse release ending on 29 September. The weather was sunny and clear between 18 and 24 September. During the second portion of the release, between 25 and 29 September, the weather became overcast. Finally, on 30 September, rain commenced until fence removal due to high water conditions on 03 October. During the first portion of the release, mean daily fence depth increased from 33.7 cm on 16 September to 60.3 cm on 21 September; water temperature fluctuated from 14°C to 18°C. The second portion of the release yielded a steady increase in fence depth from 59.0 cm on 25 September to 128.0 cm on 03 October, the final project day. Between 25 September and 03 October, water temperature oscillated between 15°C and 18°C. The two largest chinook movements occurred directly after the two pulse releases. The first peak movement of fish took place on 18 and 19 September when 1,426 adult chinook and 637 jack chinook migrated past the fence site (32.37% and 26.75% of fence enumeration, respectively). The second peak movement of fish occurred between 26 and 28 September when 1,529 adult chinook and 716 jack chinook were enumerated (34.71% and 30.16% of fence enumeration, respectively) (Nagtegaal and Carter 1998b). Daily adult and jack chinook fence counts as well as discharge rates for 1997 are displayed in Figure 22.

1998

In 1998, the enumeration fence was in operation from 05 September to 08 November with the same fence design as the previous year (Nagtegaal and Carter 1999) (Table 13). Monthly discharge rates as well as daily discharge rates with chinook counts are displayed in Figure 23 and Figure 24.

In 1998, no scheduled water release occurred.

1999

In 1999, the enumeration fence was in operation from 27 August to 30 October with the same fence design as the previous year (Nagtegaal and Carter 2000a).

During 1999, mean monthly discharge was higher than the period average between January to March, May to July, and November to December. The monthly discharge rates were similar to the period mean for April, August, and September, and slightly lower for the month of October (Figure 25). During the enumeration period, daily mean fence depth ranged from 40.0 cm to 92.5 cm and averaged 47.6 cm while water temperature ranged from 9.3°C to 20.0°C and averaged 15.0°C (Table 14).

In 1999, a single water release occurred between 07 and 16 October. On 06 October, mean fence depth was 41.3 cm and mean discharge was 6.68 m^3/s. Rain commenced on 07 October bringing the mean depth to 48.9 cm and the mean discharge to 9.21 m^3/s. On 08 October, a further increase in mean depth to 57.7 cm and mean discharge to 18.0 m^3/s was the combined result of rainfall and released water from the previous day. During the release period, water temperature fluctuated between 12.0°C and 15.0°C. The entire release period experienced steady fish movement with 1,979 adult chinook and 470 jack chinook enumerated between 07 and 16 October (51.75% and 36.40% of fence enumeration, respectively). The major peak of fish movement occurred on 08 and 09 October with 1,097 adult chinook and 197 jack chinook migrating past the fence (28.69% and 15.26% of fence enumeration, respectively). Daily adult and jack chinook fence counts as well as discharge rates for 1999 are displayed in Figure 26.

2000

In 2000, the enumeration fence was in operation from 08 September to 24 October with the same fence design as the previous year (Diewert et al. 2003)

During 2000, mean monthly discharge was lower than the period average between January to March as well as November and December. The monthly discharge rates were similar to the period mean for the remaining months throughout the year (Figure 27). During the enumeration period, daily mean fence depth ranged from 44.7 cm to 83.7 cm and averaged 54.5 cm while water temperature ranged from12.3°C to 19.0°C and averaged 15.2°C (Table 15).

In 2000, the water release occurred between 25 September and 02 October. The first two days were used to ramp discharge levels to the three day target rate of 18.5 m^3/s. The release was then ramped down over two days before returning to regular levels. Heavy rainfall commenced on 28 September and continued until 01 October further increasing river discharge. Depth at the fence site increased from 45.0 cm on 24 September to 64.0 cm on 27 September; water temperature fluctuated from 14°C to 19°C. During the period of 26 September to 02 October, 2,555 adult chinook and 586 jack chinook migrated past the fence site (54.75% and 42.13% of fence enumeration,

respectively) (Diewert et al. 2003). Daily adult and jack chinook fence counts as well as discharge rates for 2000 are displayed in Figure 28.

2001

In 2001, the enumeration fence was in operation from 04 September to 01 November with the same fence design as the previous year (Hop Wo et al. 2004).

During 2001, mean monthly discharge was lower than the period average between January to April. The monthly discharge rates were similar to the period mean for the remaining months throughout the year (Figure 29). During the enumeration period, daily mean fence depth ranged from 42.7 cm to 88.5 cm and averaged 54.4 cm while water temperature ranged from 9.0°C to 18.9°C and averaged 15.3°C (Table 16).

In 2001, the water release occurred between 27 September and 03 October. The target release rate of 18.4 m^3/s was to be maintained for four days with water levels gradually ramped down over the final three days. Depth at the fence site increased from 46.0 cm on 26 September to 62.4 cm on 28 September; water temperature fluctuated between 15°C and 17°C, throughout the release period. Chinook movement primarily occurred between 28 September and 01 October when 954 adult chinook and 560 jack chinook migrated past the fence site (28.38% and 38.51% of fence enumeration, respectively) (Hop Wo et al. 2004). Peak chinook movement occurred on 28 September when 612 adults and 418 jacks were enumerated (18.21% and 28.79% of fence enumeration, respectively). Daily adult and jack chinook fence counts as well as discharge rates for 2001 are displayed in Figure 30.

2002

In 2002, the enumeration fence was in operation from 03 September to 13 November with the same fence design as the previous year (Nagtegaal et al. 2004).

During 2002, mean monthly discharge was similar to the period mean throughout the entire year (Figure 31). During the enumeration period, daily mean fence depth ranged from 49.7 cm to 77.0 cm and averaged 54.6 cm while water temperature ranged from 6.7°C to 18.3°C and averaged 13.4°C (Table 17).

In 2002, the water release occurred between 02 and 08 October. Output from the Cowichan Lake weir was gradually increased from 7.08 m^3/s to 12.74 m^3/s on 02 October and was further increased to 18.41 m^3/s the following day. The flow rate was maintained at 18.41 m^3/s for four days before being reduced to

12.74 m^3/s on 07 October and to 7.08 m^3/s on 08 October. During the release, the river discharge measured at the Island Highway Bridge increased from 5.98 m^3/s on 01 October to 14.73 m^3/s on 04 October. Water levels at the fence increased from 53.0 cm on 01 October to 67.0 cm on 04 October. Weather at the fence site was sunny and dry before the water release; however, rainfall commenced on 02 October and continued until 04 October. Chinook movement was prominent throughout the release period with 1,135 adult chinook and 434 jack chinook migrating past the fence site between 03 October and 08 October (41.35% and 26.03% of fence enumeration, respectively) (Nagtegaal et al. 2004). Daily adult and jack chinook fence counts as well as discharge rates for 2002 are displayed in Figure 32.

2003

In 2003, the enumeration fence was in operation from 08 September to 16 October with the same fence design as the previous year. High flows and river flooding resulted in the fence being discontinued on 16 October (unpublished data).

During 2003, mean monthly discharge was higher than the period average in the months of January, March, April, and October. The monthly discharge rates were similar to the period mean for the remaining months throughout the year (Figure 33). During the enumeration period, daily mean fence depth ranged from 43.0 cm to 92.0 cm and averaged 47.0 cm while water temperature ranged from 9.7°C to 18.0°C and averaged 15.5°C (Table 18).

In 2003, three water releases occurred. A 24-hour water release with a target discharge rate of 11.33 m^3/s occurred on 06 October. The result in river discharge is not available; however, water levels at the fence site increased from 43 cm to 59 cm on 06 October. Weather for 05 and 06 October was recorded as being a combination of sun and clouds. Peak fish movement occurred on 06 and 07 October, when 659 adult chinook and 636 jack chinook migrated past the fence site (48.81% and 50.88% of fence enumeration, respectively) (Unpublished data). Daily adult and jack chinook fence counts as well as fence depth for 2003 are displayed in Figure 34.

The second 24-hour release occurred on 12 October when 16.99 m^3/s was released from the weir. River discharge, at the Island Highway Bridge, increased from 3.90 m^3/s on 11 October to 13.6 m^3/s on the following day. Water levels at the fence site increased from a daily mean of 45 cm on 11 October to a peak of 80 cm on 12 October. Daily mean water temperatures declined from 15.0°C on 10 October to 13.0°C on 12 October. Rainfall was present before and during the water release. Peak fish movement occurred on 12 and 13 October when 321 adult chinook and 270 jack chinook migrated past the fence site (23.78% and 21.60% of fence enumeration, respectively) (Unpublished data).

Daily adult and jack chinook fence counts as well as fence depth for 2003 are displayed in Figure 34.

The third water release commenced on 15 October when 14.16 m^3/s was to be released. However, heavy rainfall commenced on 15 October, resulting in river discharge rates increasing from 6.91 m^3/s on 15 October to 52.2 m^3/s on 16 October. By the following day, discharge had tripled to 164 m^3/s and by 20 October discharge had reached 311 m^3/s with the weir gates wide open. The fence enumeration program was discontinued on 16 October due to dangerously high water conditions. Fish movement started to increase with 164 adult chinook and 92 jack chinook counted during the first two shifts on 16 October (12.15% and 7.36% of fence enumeration, respectively) (Unpublished data). Daily adult and jack chinook fence counts as well as fence depth for 2003 are displayed in Figure 34.

2004

In 2004, the fence was installed with updated panels. All cross-members joining the PVC pipes were made entirely of aluminium, therefore eliminating the need for gear clamps to secure the pipes. The new panel design successfully reduced the areas where leaves could become entangled in the fence. The fence was installed during the week of 07 – 10 September and in operation until 28 October (unpublished data).

During 2004, mean monthly discharge was below than the period average between February to August. It is worth noting that the first two weeks of September also had lower than average flows, with a mean discharge rate of 3.81 m^3/s. The monthly discharge rates were similar to the period mean for the remaining months throughout the year (Figure 35). During the enumeration period, daily mean fence depth ranged from 43.3 cm to 85.0 cm and averaged 65.9 cm while water temperature ranged from 12.0°C to 17.0°C and averaged 14.6°C (Table 19).

In 2004, due to water availability, a new water release strategy was employed. This new release approach allowed for a longer sustained water release with planned increases to test two main interests. The first was to determine how much water discharge the new fence design could sustain without the risk of damage. It was determined that the maximum discharge the fence can incur while still being safely operated is 800 ft^3/s or 22.65 m^3/s. However, this is very dependant of the amount and type of debris within the river. The second was to determine if steady water flows would encourage fish movement past the fence site as opposed to the traditional pulse release of drier years.

The release strategy commenced on 16 September when water output at the weir increased from 4.25 m^3/s to 7.08 m^3/s. The next increase occurred on

24 September when river discharge was doubled to 14.16 m^3/s. Smaller alterations in weir outflow took place on 29 September when flow increased to 15.57 m^3/s and 02 October to 16.99 m^3/s. On 08 October, the outflow reached the season peak at 22.65 m^3/s, but was reduced the following day to 19.82 m^3/s, and on 10 October it was further reduced to 16.99 m^3/s. The final alteration in weir discharge occurred on 14 October when flow was increased to 22.65 m^3/s.

Peak chinook movement occurred on 25 September when 405 adult chinook and 239 jack chinook migrated past the fence site (20.23% and 23.83% of fence enumeration, respectively). Two smaller chinook migration peaks occurred on days corresponding to increased output from the weir at Cowichan Lake. The first occurred on 17 and 18 September when 283 adult and 110 jack chinook migrated past the fence (14.14% and 10.97% of fence enumeration, respectively). The second occurred on 09 October when 131 adult and 49 jack chinook swam upstream (6.54% and 4.89% of fence enumeration, respectively) (Unpublished data). Daily adult and jack chinook fence counts as well as discharge rates for 2004 are displayed in Figure 36.

Nanaimo River

Water released from the dams in the Nanaimo River Watershed must follow a more complicated path, than in the Cowichan River, before reaching the Nanaimo River enumeration fence. The Fourth Lake Dam releases water 80 feet below the top of the dam and as a result the water temperature is lower than on the lake's surface. River temperatures within the Nanaimo River during the summer can vary by more than 10°C from the area just below Fourth Lake to the Bore Hole (just upstream of the Island Highway Bridge). Once water leaves Fourth Lake, it must feed into Third, Second and then First Lake before continuing downstream (Figure 2). While Third Lake is very small (0.13 km^2), Second Lake has a surface area of 1.81 km^2 and First Lake an area of 1.96 km^2. A certain amount of mixing of water will occur as the flows reach Second Lake and then First Lake; this is where water temperatures will start to reach equilibrium. It takes approximately 48 hours for water released at Fourth Lake to reach the fence resulting in increase depth. A summary of all water releases and associated chinook movements at the Nanaimo River enumeration fence is presented in Table 2.

1995

In 1995, a floating resistance board type fence was installed in the Nanaimo River. This fence was located approximately 1.5 kilometres upstream of the estuary, just downstream of the Cedar Bridge. Enumeration commenced 08 August to 16 October and it was felt that most of the chinook run was recorded. Due to fish holding below the fence, chinook were herded upstream

through the fence using a beach seine net on 08 September (note: this appears in the data set as a peak number of enumerated chinook). During the season, the only problem arose on 10 October when algal build-up resulted in the fence becoming submerged allowing some salmon to swim over unaccounted (Carter and Nagtegaal 1997).

During the enumeration, all three months, August, September, and October were below the ten year mean with average discharge rates of 4.50 m^3/s, 4.90 m^3/s, and 27.81 m^3/s, respectively (Figure 37). During the enumeration period, daily mean fence depth ranged from 54 cm to 113 cm and averaged 74.4 cm while daily mean water temperature ranged from 11°C to 20°C and averaged 17.2°C (Table 20).

The only scheduled release in 1995 commenced at the Fourth Lake Dam site on 24 September, the second part of the release occurred at Jump Lake on 25 September. A target release rate of 11.3 m^3/s was maintained until the end of the release period on 28 September. Fence depth increased from 63 cm on 23 September to 85 cm on 25 September; temperature remained at 17°C for most of the release. Two days after the release commenced, on 26 September, 1,122 adult chinook and 1,889 jack chinook proceeded past the fence (58.96% and 56.83% of enumeration, respectively) (Carter and Nagtegaal 1997). This was the largest movement of chinook past the fence during the season. Daily adult and jack chinook fence counts as well as discharge rates for 1995 are displayed in Figure 38.

1996

In 1996, the enumeration fence was in operation from 14 August to 14 October. The area above the trap box was modified to increase flow in order to better attract salmon through the corridor and upstream of the fence; however, fish were still hesitant in migrating past the fence. As a result, some fish were again herded through the fence on 17 September (note: this appears in the data set as a peak number of enumerated chinook) (Carter and Nagtegaal 1998).

During the 1996 enumeration, all three months, August, September, and October were below the ten year mean with average discharge rates of 4.31 m^3/s, 4.85 m^3/s, and 29.07 m^3/s, respectively (Figure 39). During the enumeration period, daily mean fence depth ranged from 68.0 cm to 104.3 cm and averaged 68.0 cm while daily mean water temperature ranged from 11.0°C to 21.0°C and averaged 16.2°C (Table 21).

There were two scheduled water releases which occurred in 1995. The first release commenced on 26 September, ended on 29 September, and had a target discharge rate of 11.3 m^3/s. This resulted in an increase in average daily fence depth from 65.0 cm on 25 September to 84.3 cm on 27 September, a 19.3

cm increase. During the water release period, seven adult chinook and 15 jack chinook migrated past the fence site (0.56% and 1.56% of fence enumeration, respectively) (Carter and Nagtegaal 1998). Daily adult and jack chinook fence counts as well as discharge rates for 1996 are displayed in Figure 40.

The second water release occurred between 11 and 14 October and had an identical discharge rate of 11.3 m^3/s. This pulse was combined with some rain which resulted in an increased daily mean fence depth from 71.3 cm on 10 October to 104.3 cm on 14 October. Between 11 October and 14 October, 132 adult chinook and 29 jack chinook migrated past the fence site (10.65% and 3.01% of fence enumeration, respectively) (Carter and Nagtegaal 1998). Daily adult and jack chinook fence counts as well as discharge rates for 1996 are displayed in Figure 40.

1997

In 1997, the enumeration fence was in operation from 08 September to 06 October with the same fence design as the previous year. Due to relatively higher flows then the previous two years fish swam through the trap box uninhibited. The fence was removed early due to debris sinking portions of the fence which allowed uncounted fish to swim past (Carter and Nagtegaal 1999).

During 1997, mean monthly discharge was greater than the ten year average for most of the year (Figure 41). During September, the discharge rate was 14.72 m^3/s or three times above average. Rainfall was recorded on ten of the 24 counting days; temperatures ranged from 14°C to 22°C and averaged 16.5°C (Table 22).

There was one scheduled water release in 1997 which occurred between 11 and 14 September. During the release, the weather conditions were recorded as being cloudy with rain commencing on 14 September and continuing until 18 September. This resulted in an increase in daily mean fence depth from 61.6 cm on 10 September to 127.0 cm on 18 September. During the water release, 46 adult and 62 jack chinook migrated past the fence site (6.73% and 32.80% of enumeration, respectively). The largest peak of the season occurred after a few more days of rain on 17 September when 465 adult and 49 jack chinook were recorded (67.98% and 25.93% of enumeration, respectively). It is worth noting the fence was only in operation long enough to give a partial estimate of the entire chinook run. Daily adult and jack chinook fence counts as well as discharge rates for 1997 are displayed in Figure 42.

1998

In 1998, the enumeration fence was relocated to a site known as "San Salvadore", approximately 200 metres upstream of the Cedar Bridge (Figure Map). This location is narrower than the previous as well as under less tidal influence. The fence was in operation from 05 September to 19 October (Carter and Nagtegaal 2000).

During 1998, discharge rates were above average in the late fall and winter months while they were below average during the spring, summer, and early fall months (Figure 43). Rainfall was recorded on ten of 46 enumeration days while water temperatures ranged from 7°C to 24°C and averaged 18.2°C in September and 14.0°C in October (Table 23).

There was one scheduled water release in 1998 which occurred between 24 and 28 September with a target release rate of 11.3 m^3/s. During the release, daily fence depth increased from 24.0 cm on 24 September to 28.0 cm on 25 September. After raining on 25 September, the depth continued to increase to 36.0 cm on 26 September and peaked at 47.3 cm on 28 September. The peak movement of fish in 1998 was recorded on 27 September when 418 adult chinook and 101 jack chinook migrated past the fence (39.89% and 16.50% of enumeration, respectively). Daily adult and jack chinook fence counts as well as discharge rates for 1998 are displayed in Figure 44.

1999

In 1999, the enumeration fence was operational by 21 September before being "washed out" due to high water and improper anchoring on 04 October. As a result, a reliable chinook count was not possible (Carter et al. 2003).

During 1999, discharge rates were higher than average in February as well as May to July and November. The remaining months exhibited mean discharge rates similar to the ten year average (Figure 45). In the two weeks of fence operation, daily mean depth ranged from 31.7 cm to 56.0 cm and averaged 43.8 cm. Mean daily water temperature ranged from 12.0°C to 18.0°C and averaged 14.3°C (Table 24).

In 1999, a single water release occurred between 01 and 04 October and had a target discharge rate of 14.7 m^3/s. Due to the fence being discontinued within two weeks of installation no analysis was possible. Daily adult and jack chinook fence counts as well as discharge rates for 1999 are displayed in Figure 46.

2000

In 2000, the enumeration fence was in operation from 06 September to 18 October with new fence anchors installed (Carter et al. 2003).

During 2000, discharge rates were close to average for August, September, and October (Figure 47). Rainfall was recorded on seven of 42 enumeration days while water temperatures ranged from 10°C to 19°C and averaged 15.1°C in September and 11.4°C in October (Table 25).

There was one scheduled water release in 2000 which occurred between 25 September and 02 October. The targeted daily release rates from Fourth Lake were as follows: 25 September, 14.87 m^3/s; 26 September, 14.87 m^3/s; 27 September, 10.62 m^3/s; and 28 September, 7.08 m^3/s. By 29 September, the release rate at Fourth Lake was set back to 2.83 m^3/s. Between the period of 29 September and 02 October a constant 1.42 m^3/s was released from Jump Lake. During the water release, daily fence depth increased from 17.0 cm on 26 September to 39.3 cm on 28 September, before peaking at 45.0 cm on 30 September (Table X). Chinook movement peaked between 27 and 28 September when 434 adult chinook and 447 jack chinook were enumerated (48.98% and 62.52% of enumeration, respectively). Daily adult and jack chinook fence counts as well as discharge rates for 2000 are displayed in Figure 48.

2001

In 2001, the enumeration fence was in operation from 10 September to 30 October with the same fence design as the previous year (Hop Wo et al. 2003).

During 2001, the period of April to December had mean discharge rates similar to the ten year average, while January to March mean rates were slightly lower than average (Figure 49). Rainfall was recorded on ten of 52 enumeration days while water temperatures ranged from 8°C to 19°C and averaged 15.7°C in September and 10.6°C in October (Table 26).

In 2001, the scheduled water release occurred between 24 and 27 September. The daily target release rates from Fourth Lake were as follows: 24 September, 14.87 m^3/s; 25 September, 14.87 m^3/s; 26 September, 10.62 m^3/s; and 27 September, 7.08 m^3/s. During these four days, 2.83 m^3/s was released from Jump Lake. During the water release, daily fence depth increased from 20.7 cm on 24 September to 47.3 cm on 28 September. Rainfall was recorded on 26 and 29 September which added to increased river discharge during the release. The greatest movement of chinook was recorded between 26 and 28 September when 310 adult chinook and 203 jack chinook migrated past the fence (15.94% and 23.88% of enumeration, respectively). Daily adult and jack

chinook fence counts as well as discharge rates for 2001 are displayed in Figure 50.

2002

In 2002, the enumeration fence was in operation from 04 September to 28 October with the same fence design as the previous year (Carter et al. 2004).

During 2002, mean monthly discharge rates were similar to the ten year average (Figure 51). Rainfall was recorded on two of 55 days, 02 and 22 October. Water temperatures at the fence site ranged from 8°C to 20°C and averaged 16.3°C in September and 11.3°C in October (Table 27).

In 2002, the scheduled water release occurred between 30 September and 03 October. The daily target release rates from Fourth Lake were as follows: 30 September, 14.87 m^3/s; 01 October, 14.87 m^3/s; 02 October, 10.62 m^3/s; and 03 October, 7.08 m^3/s. Rainfall occurred on 02 October combined with an additional 1.42 m^3/s water released from Jump Lake. During the water release daily mean fence depth increased from 25.0 cm on 30 September to 43.3 cm on 03 October. The greatest movement of chinook in the season occurred between 02 and 04 October when 763 adult chinook and 295 jack chinook migrated past the fence (69.43% and 57.17% of enumeration, respectively). Daily adult and jack chinook fence counts as well as discharge rates for 2002 are displayed in Figure 52.

2003

In 2003, the enumeration fence was in operation from 12 September to 12 October with the same fence design as the previous year. High water in October caused flooding and allowed fish to swim around the fence ending the enumeration period early. During the early portions of the enumeration period viewing conditions were good; however, in October viewing conditions were either moderate or poor. This most likely increased the error of misidentifying salmon species as the season progressed (unpublished data).

During 2003, mean monthly discharge levels between May and September were lower than the ten year average (Figure 53). Rainfall was recorded on five of 31 days; water temperatures ranged from 10°C to 17°C and averaged 14.1°C in September and 13.4°C in October (Table 28).

In 2003, the scheduled water release occurred between 06 and 10 October. The target release rates from Fourth Lake were as follows: 06 October, 10.11 m^3/s; 07 October, 10.11 m^3/s; 08 October, 10.11 m^3/s; and 09 October, 5.66 m^3/s. Water was released from Jump Lake as follows: 08 October, 4.25 m^3/s; 09

October, 4.25 m^3/s; and 10 October, 1.98 m^3/s. Rainfall during the release was recorded on 07 and 09 October. Daily fence depth increased from 30.7 cm on 06 October to 76.7 cm on 10 October. The greatest movement of chinook was between 07 and 09 October when 1,001 adult chinook and 410 jack chinook migrated past the fence (68.23% and 75.51% of enumeration, respectively). It is worth noting that because the enumeration was discontinued earlier than usual, the proportion of fish migrating during the water release would be significantly higher than if a full run enumeration was available. Daily adult and jack chinook fence counts as well as discharge rates for 2003 are displayed in Figure 54.

DATA ANALYSIS

The Wilcoxon paired-sample test (Zar 1984) was chosen to investigate a possible relationship between scheduled water releases and chinook migration past the enumeration fence. A one-tailed test with $\alpha = 0.05$ was employed.

The data were stratified by three criteria:

1. River
2. Year
3. Spawning strategy (adult vs jack)

The hypotheses tested were as follows:

H_O: Chinook migration past the fence site 48 hours after increased fence depth due to a scheduled water release is less than or equal to chinook migration past the fence site 48 hours before increased fence depth due to a scheduled water release.

H_A: Chinook migration past the fence site 48 hours after increased fence depth due to a scheduled water release is greater than chinook migration past the fence site 48 hours before increased fence depth due to a scheduled water release.

Cowichan River

The 2004 Cowichan River data were not included in the Wilcoxon paired-sample analysis because this test was designed to compare pulse releases.

Adult Chinook

Using the Wilcoxon paired-sample test, 18 paired comparisons were made for scheduled water releases on the Cowichan River for adult chinook. The null hypothesis was found to be rejected ($T_{-}=1$, $df=18$, $\alpha=0.05$, $p<0.0005$).

Jack Chinook

Using the Wilcoxon paired-sample test, 18 paired comparisons were made for scheduled water releases on the Cowichan River for jack chinook. The null hypothesis was found to be rejected ($T_{-}=1$, $df=18$, $\alpha=0.05$, $p<0.0005$).

Nanaimo River

Adult Chinook

Using the Wilcoxon paired-sample test, ten paired comparisons were made for scheduled water releases on the Nanaimo River for adult chinook. The null hypothesis was found to be rejected ($T_{-}=4$, $df=10$, $\alpha=0.05$, $p<0.01$).

Jack Chinook

Using the Wilcoxon paired-sample test, ten paired comparisons were made for scheduled water releases on the Nanaimo River for jack chinook. The null hypothesis was found to be rejected ($T_{-}=6$, $df=10$, $\alpha=0.05$, $p<0.025$).

Data Summary

The purpose of the Wilcoxon paired-sample test was to analyse the movement of chinook past the enumeration fences during scheduled water releases. This non-parametric statistical test was chosen because it allows the comparisons of chinook movements with different run sizes for a specific year.

Stratifying data for the Wilcoxon paired-sample test by three criteria was justified by the following reasons:

1. River: It was felt that the two rivers were distinct enough to allow for separate analysis. Major differences between the two watersheds include: river morphology, river hydrology, urbanization, chinook life history strategies, and water release mechanisms.

2. Year: Stratification by year allowed for annual variation in water release strategies, weather, river flows, and run size.

3. Spawning strategy (adult vs jack): Adult and jack chinook were separated due to differences in behaviour and run timing.

It was decided to create a hypothesis that compared fish movement intervals of 48 hours in order to minimize the potential impacts of contributing factors. By keeping the interval of fish movement relatively short, factors associated with "natural" run timing are minimized. This would help control for a scenario in which the biological pressures associated with spawning (i.e. chinook becoming ripe) encouraged fish to migrate past the fence site regardless of water levels. It is assumed that as the season progresses, this biological urge would become stronger. Therefore, by keeping the analysis confined to two, 48-hour windows, the affects associated with spawning pressures are reduced. It was also felt that 48 hours provided a reasonable amount of time to measure the potential upstream migration of chinook associated with an increase in water levels at the fence site.

Fence depth was chosen rather than river discharge to denote the arrival of water at the fence site associated with a scheduled release. This method was preferred to help control the amount of lag time between when water is released at the weir and when it arrives at the fence site.

The results of the Wilcoxon paired-sample test performed on the Cowichan River and the Nanaimo River adult and jack chinook provide only limited information on the effects of water releases. All four tests support the hypothesis that water releases encourage fish to migrate past the enumeration fences. However, this statistical test cannot make inferences on how much farther upstream chinook migrate past fence sites, nor can conclusions be drawn on whether water releases aid chinook in migrating upstream towards the enumeration fences. A tagging study would be better suited to answer such questions.

ENVIRONMENTAL AND WATER RELEASE INFORMATION

Cowichan River

When looking at the 15 multi-day water releases which occurred in the Cowichan River, peak chinook movements generally occurred within a 24-hour period, except in 1990 (72 hours), 1997 (48 hours) and 1999 (48 hours) (Figures 3 – 36). There have also been successful 24-hour water releases which have aided in chinook migration past the fence site. However, a success or failure can only be assessed at the fence site. Although a 24-hour release can aid fish in migrating past the fence, it is probably not enough to allow chinook to reach the

spawning grounds. When possible, a two-day release is recommended in aiding chinook past the fence as well as past hazards upstream of the fence.

When assessing optimum discharge rates for a release, one must consider weather conditions such as rain. Of the ten water releases conducted with periods of sunny, dry weather, four had poor results (<10%) in encouraging chinook to move. Three of these four releases had the three lowest discharge rates with peaks of less than 12 m^3/s (424 ft^3/s). Alternatively, a peak mean daily discharge rate of 13.2 m^3/s (466 ft^3/s) on 06 October 1994 aided 1,853 adult chinook (36.69% of total enumeration) in migrating past the fence. This was in conjunction with a peak daily discharge rate of 16.1 m^3/s (569 ft^3/s) being released from Cowichan Lake. It is recommended that a minimum discharge rate of 16.1 m^3/s (569 ft^3/s) be released from Cowichan Lake for water release purposes.

Nanaimo River

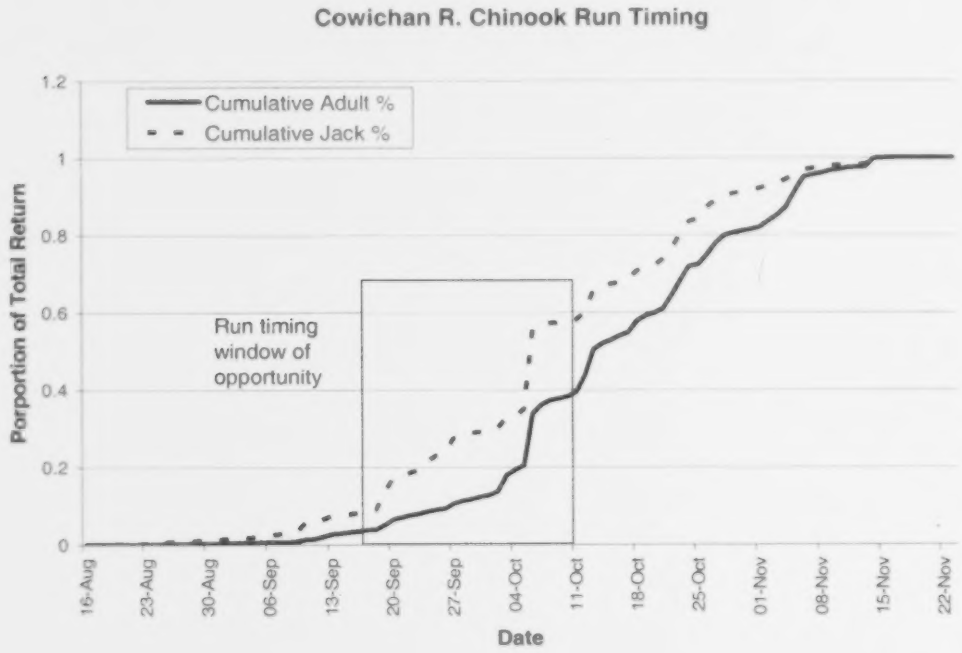
All scheduled water releases on the Nanaimo River Watershed were multi-day releases and as a result the assessment of a 24-hour release is not available. Six of the nine water releases had a majority of fish movement within a 24-hour period, the exceptions being 2001, 2002, and 2003. As most water releases within the Nanaimo River would be considered successes, it would seem that maintaining the current strategy of three and four day pulse releases would be appropriate. When looking at releases for all years, it become evident that peak fish movement generally does not occur until the second day of the release (Figure 39 – 54). Therefore, it is recommended that the minimum length of a release be at least two days, as a one day release would appear to move few fish.

Of the nine water releases which could be assessed, the two releases with the lowest peak daily discharge rates also had the poorest results with regards to chinook migration. The remaining seven releases had successes in aiding chinook migration past the fence. A minimum discharge rate of 10.8 m^3/s (382 ft^3/s) aided in the migration of 1,112 adult chinook on 26 September, 1995 (58.96% of total enumeration). Even with the new fence location, 14.87 m^3/s (525 ft^3/s) of water released at Fourth Lake resulted in the migration of 763 adult chinook between 02 and 04 October, 2002 (69.43% of total enumeration). The recommended minimum discharge rate from Fourth Lake should be at least 14.87 m^3/s (525 ft^3/s).

ADDITIONAL WATER RELEASE CONSIDERATIONS

Many factors need to be considered before deciding on the specifics of a water release. Details for consideration are as follows:

- The release must be synchronised with the typical migration timing of chinook as to ensure they are 'ready' to migrate upstream. This generally occurs in the last week of September or the first week of October and can be estimated by comparing a current cumulative run timing curve with historical values. The larger the number of fish holding in the lower river and estuary the greater the likelihood of success.



- Another consideration is the ramping down of a water release, which will lessen the chance of stranding juvenile fish rearing in-river. Through several attempts to minimise the impact of changes in water flow, we have determined that a stepped two day ramping down period of the water levels after a water release is sufficient to minimise negative impacts on juvenile fish.

- In-river activity may cause a reduction in upstream migration during a water release. We have observed that since chinook salmon are easily spooked by in-river activity, it is also recommended that hatchery broodstock collection as well as First Nations harvesting be suspended during the period of a water release in order to encourage chinook to migrate upstream unobstructed.

Timing the release during the least busy time in the week (weekday vs weekend) may also be beneficial as there would be less activity on the river from the general public.

- Timing the water release to coincide with the natural diel movement times of the fish may also be beneficial. From fence information for both Cowichan and Nanaimo, we have recorded that chinook upstream migration peaks generally in the morning, between 0700 and 1000 hours (Figure 55). Optimal timing of water release is therefore assumed to be such that the increase in flow occurs during these morning hours in the lower river.

- Water releases should be timed when environmental conditions which mimic a rain event occur. Environmental conditions including cloudy, cooler days, or actual rainfall are more beneficial in aiding upstream migration than clear sunny weather.

- Timing water releases to coincide with high tides may also be beneficial in increasing the success of a water release as more fish are drawn towards the estuary during high water. Fish tend to move in and out of the lower river along with tidal movement.

- As the first pulse flow is usually the most successful, it must be considered the most important. If there are doubts as to the opportunity of a second pulse it seems prudent to choose the most optimal conditions (maximum discharge, etc.) for the first release rather than opting for two pulses of lower discharge rates.

2004 Cowichan River Water Release

Due to plenty of rainfall in September and October water conservation at the Cowichan Lake Weir was less of a concern than usual. This allowed the new fence design to be tested under various controlled discharge levels. It was determined that 22.65 m^3/s (800 ft^3/s) was the maximum discharge the new fence design can withstand while being safely operated and still functioning properly. This discharge rate is very dependant on floating debris within the river, such as logs, stumps, and large amounts of leaves. If too much floating debris collects on the fence panels, portions of the fence will become submerged allowing uncounted fish to swim upstream. Larger debris, such as logs and stumps, can cause serious damage to the fence panels and the counting tower.

As Cowichan Lake approaches maximum capacity, knowledge of the maximum output discharge becomes important in maintaining control of the weir. If water cannot be released from the weir before maximum capacity is reached, water will spill over the weir and river discharge can no longer be controlled.

Scheduled lower discharge levels have been successful in facilitating fence removals.

Fish movement during 2004 was more spread out into various smaller peaks when compared to the previous five years. This is most likely due to a difference in weather conditions which allowed for a more continuous release of water rather than the traditional pulse release. When possible a continuous water release would be preferred as fish would be able to reach spawning areas uninhibited and with less stress induced by holding in the lower river.

ACKNOWLEDGEMENTS

The Authors would like to thank Dr. Rob Houtman of Fisheries and Oceans Canada for his help with statistical analyses. Lynne Campo of Water Survey Canada is gratefully acknowledged for her help in obtaining discharge records. We thank Brian Tutty, DFO habitat biologist, for his work and involvement in the initial stages and development of the water management plans. We thank NorskeCanada, Land and Water British Columbia, Cowichan River Hatchery, and Cowichan Tribes for their contribution towards water management of the Cowichan River. We thank Land and Water British Columbia, Greater Nanaimo Water District, City of Nanaimo, Pope and Talbot Limited, and Snuneymuxw First Nation for their contribution to water management on the Nanaimo River.

REFERENCES

Blackman, B. 1981. Nanaimo River Stock Assessment and enhancement proposals. 35+ p. (only chinook section available for Nanaimo River Library).

Brahniuk, R., Hurst, B., and Tutty, B. 1993. Nanaimo River Salmon Management contingency plan: An overview. Discussion paper. Edited by Dr. B. Riddell, Pacific Biological Station. 20 p.

Burt, D.W., and Robert, C.B. 2002. A review of environmental factors affecting the production of Cowichan River chinook salmon. Draft. Nanaimo, BC. 39 p.

Carter, E.W., and Nagtegaal, D.A. 1997. A preliminary report on the adult chinook productivity study conducted on the Nanaimo River during 1995. Can. Manuscr. Rep. Fish. Aquat. Sci. 2414: 31 p.

Carter, E.W., and Nagtegaal, D.A. 1998. A preliminary report on the adult chinook productivity study conducted on the Nanaimo River during 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2450: 29 p.

Carter, E.W., and Nagtegaal, D.A. 1999. Adult chinook escapement conducted on the Nanaimo River during 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2482: 27 p.

Carter, E.W., and Nagtegaal, D.A. 2000. Adult chinook escapement assessment conducted on the Nanaimo River during 1998. Can. Manuscr. Rep. Fish. Aquat. Sci. 2527: 29 p.

Carter, E.W., Nagtegaal, D.A., Hop Wo, N.K., and Jones, K.E. 2003. Adult chinook escapement assessment conducted on the Nanaimo River during 1999 and 2000. Can. Manuscr. Rep. Fish. Aquat. Sci. 2653: 58 p.

Carter, E.W., Nagtegaal, D.A., and Hop Wo, N.K. 2004. Adult chinook escapement assessment conducted on the Nanaimo River during 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2691: 41 p.

Diewert, R.E., Nagtegaal, D.A., Carter, E.W., and Jones, K.E. 2003. Adult chinook escapement assessment conducted on the Cowichan River during 2000. Can. Manuscr. Rep. Fish. Aquat. Sci. 2642: 48 p.

Healey, M.C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). *In* Pacific salmon life histories. Edited by C. Groot and L. Margolis. UBC Press, Vancouver. pp. 313-393.

Hop Wo, N.K., Carter, E.W., Nagtegaal, D.A., and Jones, K.E. 2003. Adult chinook escapement assessment conducted on the Nanaimo River during 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2654: 38 p.

Hop Wo, N.K., Nagtegaal, D.A., Carter, E.W., and Jones, K.E. 2004. Adult chinook escapement assessment conducted on the Cowichan River during 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2645: 45 p.

Lister, D.B., Walker, C.E., and Giles, M.A. 1971. Cowichan River chinook salmon escapements and juvenile production, 1965-1967. Department of Fisheries and Forestry, Tech. Rep. 1971-3.

Nagtegaal, D.A., Candy, J., and Riddell, B. 1994a. A preliminary report of the chinook productivity study conducted on the Cowichan River during 1990 and 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2265: 71 p.

Nagtegaal, D.A., Candy, J., and Riddell, B. 1994b. A preliminary report of the chinook productivity study conducted on the Cowichan River during 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2268: 73 p.

Nagtegaal, D.A., Candy, J., and Riddell, B. 1995a. A preliminary report of the chinook productivity study conducted on the Cowichan River during 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2315: 84 p.

Nagtegaal, D.A., Candy, J., and Riddell, B. 1995b. A preliminary report of the adult chinook productivity study conducted on the Cowichan River during 1994. Can. Manuscr. Rep. Fish. Aquat. Sci. 2331: 62 p.

Nagtegaal, D.A., Candy, J., and Riddell, B. 1996. A preliminary report of the adult chinook productivity study conducted on the Cowichan River during 1995. Can. Manuscr. Rep. Fish. Aquat. Sci. 2366: 63 p.

Nagtegaal, D.A., and Carter, E.W. 1998a. Adult chinook escapement assessment conducted on the Cowichan River during 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2449: 65 p.

Nagtegaal, D.A., and Carter, E.W. 1998b. Adult chinook escapement assessment conducted on the Cowichan River during 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2466: 53 p.

Nagtegaal, D.A., and Carter, E.W. 1999. Adult chinook escapement assessment conducted on the Cowichan River during 1998. Can. Manuscr. Rep. Fish.. Aquat. Sci. 2501: 51 p.

Nagtegaal, D.A., and Carter, E.W. 2000a. Adult chinook escapement assessment conducted on the Cowichan River during 1999. Can. Manuscr. Rep. Fish. Aquat. Sci. 2544: 59 p.

Nagtegaal, D.A., and Carter, E.W. 2000b. Results of rotary auger trap sampling in the Nanaimo River, 1999. Can. Manuscr. Rep. Fish. Aquat. Sci. 2502: 24 p.

Nagtegaal, D.A., Carter, E.W., Hop Wo, N.K., and Jones, K.E. 2004. Adult chinook escapement assessment conducted on the Cowichan River during 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2655: 49 p.

Nagtegaal, D.A., Starr, P.J., and Riddell, B. 1994c. A preliminary report on the chinook productivity study conducted on the Cowichan River, 1988 and 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2233: 53 p.

Water Survey of Canada. 2004. Real – time hydrometric data. http://scitech.pyr.ec.gc.ca/waterweb/main.asp (accessed 30 June, 2004).

Zar, J.A. 1984. Biostatistical Analysis. Prentice-Hall Inc, Englewood Cliffs, New Jersey. 718 p.

Table 1. Annual water releases and associated chinook movements, Cowichan River, 1988 - 2004

Year	Pulse Release Date	Peak Discharge[1]	Change in Fence Depth [2]	Date of Fish Movement	Adult Chinook Count	Adult Chinook % of Enum.	Jack Chinook Count	Jack Chinook % of Enum.	Comments
1988	24-Sep to 27-Sep	17.8 m^3/s	30 cm	25-Sep to 05-Oct	2869	55.56%	2595	61.15%	Water release was combined with rain, which continued to fall after the pulse date.
1989	01-Oct to 02-Oct	8.27 m^3/s	10 cm	02-Oct	104	7.85%	87	8.51%	No rain. Two day water release.
1990	22-Sept to 26-Sep	15.8 m^3/s	18.4 cm	23-Sept to 27 Sept	1282	30.79%	5421	35.67%	No rain, clear and sunny.
1990	03-Oct (Start Date)	19.9 m^3/s	27.1 cm	04-Oct to 08-Oct	1627	39.07%	3191	20.99%	Water release was combined with rain.
1991	04-Oct to 09-Oct	20.2 m^3/s	11.3 cm	08-Oct	265	11.16%	142	8.73%	No rain, clear and sunny. Fish movement was less distinct than usual.
1992	27-Sept to 05-Oct	12.5 m^3/s	13.6 cm	28-Sep to 05-Oct	1123	14.51%	146	3.95%	Clear and sunny. 12:00 start time. Discharge rates are estimates.
1993	26-Sep to 30-Sep	14.6 m^3/s	16.6 cm	27-Sep	105	2.08%	484	8.39%	Clear and sunny. 12:00 start time.
1994	05-Oct to 08-Oct	13.2 m^3/s	9.1 cm	06-Oct to 07-Oct	1853	36.69%	4560	34.08%	Clear and sunny. 08:00 start time.
1994	17-Oct to 20-Oct	11.9 m^3/s	10.0 cm	18-Oct	292	5.78%	330	2.47%	Clear and sunny. 08:00 start time. Discharge rates are estimates.
1995	22-Sep to 23-Sep	7.09 m^3/s	2.3 cm	22-Sep	129	1.20%	209	2.64%	Clear and sunny. 24 hour release only.
1996	-	-	-	-	-	-	-	-	No water release.
1997	17-Sep to 25 Sep	28.3 m^3/s	26.6 cm	18-Sep to 19-Sep	1426	32.37%	637	26.81%	Clear and sunny.
1997	25-Sep to 29-Sep	49.4 m^3/s	26.0 cm	26-Sep to 28-Sep	1529	34.71%	716	30.13%	Clear and sunny. This is the 2nd half of a two part release. Rain commenced on 30-Oct.
1998	-	-	-	-	-	-	-	-	No water release.
1999	07-Oct to 16-Oct	18.7 m^3/s	14.6 cm	08-Oct to 09-Oct	1097	28.69%	197	15.26%	Cloudy weather before release. Rain commenced on 07-Oct.

Table 1. (continued)

Year	Pulse Release Date	Peak Discharge[1]	Change in Fence Depth[2]	Date of Fish Movement	Adult Chinook Count	Adult Chinook % of Enum.	Jack Chinook Count	Jack Chinook % of Enum.	Comments
2000	25-Sep to 02-Oct	17.5 m^3/s	19.3 cm	26-Sep to 02-Oct	2555	54.75%	586	42.13%	Heavy Rainfall commenced 28-Sept.
2001	27-Sep to 03-Oct	16.3 m^3/s	17 cm	28-Sep to 01-Oct	954	28.38%	560	38.51%	Cloudy conditions.
2002	02-Oct to 08-Oct	14.7 m^3/s	14 cm	03-Oct to 08-Oct	1135	41.35%	434	26.03%	03-Oct to 06-Oct was the peak release rate; water release was combined with rain.
2003	06-Oct to 07-Oct	N/A	10.7 cm	07-Oct	523	38.74%	501	40.08%	Clear weather conditions. 24 hour release.
2003	12-Oct to 13-Oct	13.6 m^3/s	30.3 cm	12-Oct to 13-Oct	321	23.78%	270	21.60%	Release mixed with rain. 24 hour release.
2003	15-Oct (Start Date)	-	-	-	-	-	-	-	Release mixed with heavy rains. Fence project discontinued, 16-Oct.
2004	-	-	-	25-sep	405	20.23%	239	23.83%	Weather permitted for a increased continuous release of water rather than a pulse release.

[1] The peak discharge during a scheduled release period. Information obtained from Water Survery Canada Station 08HA011, Duncan, BC.

[2] Data is based on the difference between mean daily fence depths of pre-pulse and peak pulse flows.

Table 2. Annual water releases and associated chinook movements, Nanaimo River, 1995 - 2003

Year	Pulse Release Date	Peak Discharge[1]	Change in Fence Depth[2]	Date of Fish Movement	Adult Chinook Count	Adult Chinook % of Enum.	Jack Chinook Count	Jack Chinook % of Enum.	Comments
1995	24-Sep to 28-Sep	10.8 m^3/s	26 cm	26-Sep	1122	58.96%	1889	56.83%	Jump Lake started to release water on 25-Sep
1996	26-Sep to 29-Sep	8.56 m^3/s	19.3 cm	26-Sep to 30-Sep	7	0.56%	15	1.56%	No peak fish movement.
1996	11-Oct to 14-Oct	23.2 m^3/s	33.0 cm	11-Oct to 14-Oct	132	10.65%	29	3.01%	Water release was combined with some rain.
1997	11-Sep to 14-Sep	7.43 m^3/s	22.3 cm	11-Sep to 14-Sep	46	6.73%	62	32.80%	Steady increase in rainfull during and after pulse release.
1998	24-Sep to 28-Sep	12.8 m^3/s	23.3 cm	27-Sep	418	39.89%	101	16.50%	Rain occurred on 25-Sep.
1999	01-Oct to 04-Oct	11.9 m^3/s	15.0 cm	-	-	-	-	-	Fence removed on 04-Oct due to heavy rains.
2000	25-Sep to 02-Oct	12.0 m^3/s	28 cm	27-Sept to 28-Sep	434	48.98%	447	62.52%	Rain occurred on 29-Sep.
2001	24-Sep to 27-Sep	15.5 m^3/s	26.6 cm	26-Sep to 28-Sep	310	15.94%	203	23.88%	Rain occurred on 26-Sep and 29-Sep.
2002	30-Sep to 03-Oct	10.9 m^3/s	18.3 cm	02-Oct to 04-Oct	763	69.43%	295	57.17%	Rain occurred on 02-Oct
2003	06-Oct to 10-Oct	27.5 m^3/s	46.0 cm	07-Oct to 09-Oct	1001	68.23%	410	75.51%	Water release was combined with heavy rainfall. Enumeration discontinued on 12-Oct.

1 The peak discharge during a scheduled release period. Information obtained from Water Survery Canada Station 08HB034, Cassidy, BC.

2 Data is based on the difference between mean daily fence depths of pre-pulse and peak pulse flows.

Table 3. Daily counts and environmental information, Cowichan River enumeration fence, 1988.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
09-Sep-88	N/A	5.11	N/A	0	3	
10-Sep-88	N/A	4.91	N/A	0	26	
11-Sep-88	N/A	4.32	N/A	4	27	
12-Sep-88	N/A	4.77	N/A	0	18	
13-Sep-88	N/A	5.50	N/A	0	17	
14-Sep-88	N/A	6.89	N/A	2	31	
15-Sep-88	N/A	5.08	N/A	5	32	
16-Sep-88	54	5.00	16	1	5	
17-Sep-88	51	4.90	14	1	7	
18-Sep-88	49	4.98	14	3	29	
19-Sep-88	50	5.39	14	8	102	
20-Sep-88	49	5.09	14	15	58	
21-Sep-88	48	4.87	14	44	68	
22-Sep-88	49	5.11	14	26	67	
23-Sep-88	54	5.67	14	17	66	
24-Sep-88	53	5.39	14	9	43	Water release commenced.
25-Sep-88	65	11.00	14	60	271	
26-Sep-88	79	16.70	14	592	676	
27-Sep-88	77	17.50	14	264	327	Water release terminated.
28-Sep-88	75	16.20	15	118	126	
29-Sep-88	74	15.60	14	396	186	
30-Sep-88	72	15.00	16	516	261	
01-Oct-88	71	14.10	15	319	244	
02-Oct-88	72	13.50	15	180	143	
03-Oct-88	71	13.10	15	214	225	
04-Oct-88	71	12.30	16	112	70	
05-Oct-88	70	12.20	15	98	66	
06-Oct-88	68	11.50	15	27	9	
07-Oct-88	69	11.10	16	30	29	
08-Oct-88	66	10.70	14	79	23	
09-Oct-88	67	10.30	14	46	22	
10-Oct-88	66	9.74	14	26	14	
11-Oct-88	66	7.48	14	52	13	
12-Oct-88	60	7.63	15	31	13	
13-Oct-88	60	8.27	15	96	14	
14-Oct-88	62	8.48	14	64	33	
15-Oct-88	60	9.29	14	106	43	
16-Oct-88	69	10.50	14	98	43	
17-Oct-88	67	8.49	14	62	31	
18-Oct-88	67	8.86	12	52	18	
19-Oct-88	71	10.40	13	25	16	
20-Oct-88	83	13.20	13	269	59	
21-Oct-88	82	13.30	13	72	17	

Table 3. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
22-Oct-88	81	13.30	13	170	92	
23-Oct-88	81	13.10	13	46	18	
24-Oct-88	76	13.00	13	21	17	
25-Oct-88	71	12.40	12	99	71	
26-Oct-88	70	12.60	13	63	47	
27-Oct-88	69	12.00	12	37	24	
28-Oct-88	70	11.60	10	36	20	
29-Oct-88	68	10.90	10	31	58	
30-Oct-88	71	11.10	11	106	109	
31-Oct-88	71	12.30	12	128	39	
01-Nov-88	75	14.30	12	257	143	
02-Nov-88	85	19.60	12	31	15	
				5,164	4,244	

Table 4. Daily counts and environmental information, Cowichan River enumeration fence, 1989.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
13-Sep-89	N/A	5.19	N/A	0	8	
14-Sep-89	N/A	5.14	N/A	1	23	
15-Sep-89	N/A	4.97	N/A	0	10	
16-Sep-89	N/A	5.37	N/A	0	9	
17-Sep-89	42	5.85	N/A	3	27	
18-Sep-89	42	5.40	15	21	61	
19-Sep-89	42	5.35	15	21	29	
20-Sep-89	42	5.45	15	10	18	
21-Sep-89	42	5.37	16	16	21	
22-Sep-89	42	5.30	16	8	7	
23-Sep-89	41	5.22	15	6	21	
24-Sep-89	41	5.26	17	4	3	
25-Sep-89	41	5.42	16	11	16	
26-Sep-89	43	6.02	16	44	18	
27-Sep-89	42	5.71	15	50	32	
28-Sep-89	42	5.53	15	24	15	
29-Sep-89	42	5.49	16	29	34	
30-Sep-89	42	5.42	15	15	15	

Table 4. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
01-Oct-89	48	6.40	15	28	58	Water release commenced.
02-Oct-89	50	8.27	14	104	87	Water release terminated.
03-Oct-89	52	7.78	14	26	18	
04-Oct-89	35	5.04	13	20	8	
05-Oct-89	39	4.71	14	12	9	
06-Oct-89	38	4.19	14	28	13	
07-Oct-89	39	4.08	15	8	12	
08-Oct-89	39	4.09	15	27	16	
09-Oct-89	39	4.27	14	42	24	
10-Oct-89	39	4.48	15	40	26	
11-Oct-89	39	4.76	15	145	78	
12-Oct-89	40	5.10	14	86	69	
13-Oct-89	41	5.37	14	34	26	
14-Oct-89	41	5.80	13	6	6	
15-Oct-89	41	5.91	12	16	11	
16-Oct-89	43	5.95	11	27	3	
17-Oct-89	42	5.84	12	60	19	
18-Oct-89	42	6.13	12	68	52	
19-Oct-89	42	6.29	13	70	45	
20-Oct-89	42	6.17	13	75	27	
21-Oct-89	45	7.10	12	61	21	
22-Oct-89	52	10.20	12	78	27	
23-Oct-89	61	15.70	12	0	0	
24-Oct-89	79	22.40	12	0	0	
				1,324	1,022	

Table 5. Daily counts and environmental information, Cowichan River enumeration fence, 1990.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
12-Sep-90	14.0	5.69	19	0	10	
13-Sep-90	13.5	5.22	18	1	45	
14-Sep-90	12.6	4.91	17	8	346	
15-Sep-90	12.8	5.23	17	10	328	
16-Sep-90	13.8	5.58	18	3	168	

Table 5. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
17-Sep-90	13.3	5.37	18	10	132	
18-Sep-90	13.3	5.61	18	135	2,095	
19-Sep-90	12.7	5.56	17	40	388	
20-Sep-90	13.2	5.68	17	8	69	
21-Sep-90	13.0	5.30	16	7	156	
22-Sep-90	12.5	7.29	17	32	576	Water release commenced.
23-Sep-90	30.9	15.80	18	130	2,295	
24-Sep-90	30.5	15.50	19	115	840	
25-Sep-90	29.6	15.70	19	536	1,094	
26-Sep-90	29.6	15.10	18	265	531	Water release terminated.
27-Sep-90	25.4	12.20	18	236	661	
28-Sep-90	12.8	4.97	17	16	52	
29-Sep-90	12.0	5.11	17	96	443	
30-Sep-90	12.0	5.50	16	32	176	
01-Oct-90	12.0	5.82	17	90	327	
02-Oct-90	11.5	6.41	15	5	20	
03-Oct-90	17.5	8.38	15	7	44	Water release commenced.
04-Oct-90	32.7	19.10	16	634	1,940	
05-Oct-90	38.6	19.90	15	375	268	
06-Oct-90	37.3	19.10	14	201	204	
07-Oct-90	36.7	18.70	14	217	454	
08-Oct-90	34.2	18.10	15	200	325	
09-Oct-90	32.2	17.70	15	68	89	
10-Oct-90	32.6	17.80	15	49	84	
11-Oct-90	32.0	17.60	14	22	25	
12-Oct-90	34.8	18.60	14	37	33	
13-Oct-90	34.2	18.80	14	11	64	
14-Oct-90	34.2	19.00	13	38	46	
15-Oct-90	35.8	19.90	13	91	170	
16-Oct-90	36.0	19.30	13	31	51	
17-Oct-90	34.3	19.00	13	28	55	
18-Oct-90	39.5	22.10	13	47	20	
19-Oct-90	42.3	23.20	13	40	83	
20-Oct-90	39.2	22.60	13	20	22	
21-Oct-90	42.6	26.80	13	179	259	
22-Oct-90	40.8	26.70	13	28	108	
23-Oct-90	40.0	25.90	11	32	64	
24-Oct-90	37.0	26.50	12	11	34	
25-Oct-90	42.0	40.40	13	23	5	
				4,164	15,199	

Table 6. Daily counts and environmental information, Cowichan River enumeration fence, 1991.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
19-Aug-91	36.5	4.91	23	0	0	
20-Aug-91	36.5	4.85	22	0	0	
21-Aug-91	36.5	4.61	22	0	1	
22-Aug-91	36.2	4.68	22	0	0	
23-Aug-91	N/A	4.93	N/A	N/A	N/A	High water prohibits enumeration.
24-Aug-91	37.0	5.01	22	0	0	
25-Aug-91	36.5	5.03	18	0	0	
26-Aug-91	36.5	4.89	18	1	1	
27-Aug-91	39.0	5.44	18	0	1	
28-Aug-91	39.2	5.46	17	14	7	
29-Aug-91	41.0	7.43	17	6	5	
30-Aug-91	55.0	63.80	17	0	0	
31-Aug-91	N/A	87.90	N/A	N/A	N/A	High water prohibits enumeration.
01-Sep-91	N/A	84.90	N/A	N/A	N/A	High water prohibits enumeration.
02-Sep-91	N/A	82.50	N/A	N/A	N/A	High water prohibits enumeration.
03-Sep-91	N/A	78.20	N/A	N/A	N/A	High water prohibits enumeration.
04-Sep-91	N/A	74.20	N/A	N/A	N/A	High water prohibits enumeration.
05-Sep-91	N/A	69.00	N/A	N/A	N/A	High water prohibits enumeration.
06-Sep-91	N/A	64.80	N/A	N/A	N/A	High water prohibits enumeration.
07-Sep-91	N/A	59.40	N/A	N/A	N/A	High water prohibits enumeration.
08-Sep-91	N/A	55.70	N/A	N/A	N/A	High water prohibits enumeration.
09-Sep-91	N/A	42.70	N/A	N/A	N/A	High water prohibits enumeration.
10-Sep-91	91.0	37.90	18	4	3	
11-Sep-91	N/A	28.30	N/A	N/A	N/A	High water prohibits enumeration.
12-Sep-91	75.0	25.10	18	4	0	
13-Sep-91	72.0	24.40	19	8	2	
14-Sep-91	73.8	24.40	17	17	9	
15-Sep-91	64.1	17.10	17	4	2	
16-Sep-91	53.0	12.00	17	21	31	
17-Sep-91	54.8	13.30	18	34	62	
18-Sep-91	55.6	13.00	17	21	36	
19-Sep-91	54.3	12.60	18	8	20	
20-Sep-91	53.7	12.20	18	7	10	
21-Sep-91	53.1	12.20	17	8	11	
22-Sep-91	52.9	12.10	17	1	2	
23-Sep-91	53.3	12.30	16	10	13	
24-Sep-91	53.3	12.30	16	3	15	
25-Sep-91	53.0	11.80	16	10	15	
26-Sep-91	54.3	13.60	17	64	120	
27-Sep-91	54.9	13.70	18	43	143	
28-Sep-91	53.6	12.80	18	12	8	
29-Sep-91	53.7	11.70	17	16	11	

Table 6. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
30-Sep-91	53.3	11.50	17	53	22	
01-Oct-91	53.0	11.50	16	29	12	
02-Oct-91	52.0	11.30	16	64	29	
03-Oct-91	51.4	11.00	15	66	22	
04-Oct-91	51.5	12.40	15	23	19	Water release commenced.
05-Oct-91	59.6	20.20	16	89	71	
06-Oct-91	59.1	19.60	15	63	43	
07-Oct-91	62.0	19.50	15	17	17	
08-Oct-91	62.8	20.10	16	265	142	
09-Oct-91	62.8	20.00	16	75	14	Water release terminated.
10-Oct-91	60.4	18.00	15	31	14	
11-Oct-91	52.4	11.80	15	26	8	
12-Oct-91	52.0	11.00	16	29	12	
13-Oct-91	52.8	12.00	15	52	6	
14-Oct-91	52.2	12.10	15	25	9	
15-Oct-91	52.0	11.60	15	37	13	
16-Oct-91	53.0	12.60	15	137	52	
17-Oct-91	52.5	12.50	14	54	11	
18-Oct-91	54.5	13.50	13	46	11	
19-Oct-91	53.8	13.00	14	46	10	
20-Oct-91	53.0	12.40	14	23	6	
21-Oct-91	47.3	12.00	14	45	16	
22-Oct-91	53.0	12.10	14	21	2	
23-Oct-91	52.8	12.00	12	29	8	
24-Oct-91	57.6	15.80	12	50	29	
25-Oct-91	57.5	15.30	13	52	26	
26-Oct-91	56.3	14.80	11	20	15	
27-Oct-91	55.5	13.70	11	14	4	
28-Oct-91	46.0	13.70	10	20	29	
29-Oct-91	46.6	15.40	10	14	10	
30-Oct-91	45.3	15.70	10	57	35	
31-Oct-91	57.0	15.10	10	41	49	
01-Nov-91	56.0	14.70	11	82	62	
02-Nov-91	55.0	14.00	11	50	32	
03-Nov-91	55.0	13.40	11	29	14	
04-Nov-91	56.0	14.40	11	39	26	
05-Nov-91	39.1	15.80	11	95	59	
06-Nov-91	56.2	15.20	11	73	31	
07-Nov-91	45.9	15.40	11	10	14	
08-Nov-91	N/A	16.30	11	21	32	
09-Nov-91	56.2	16.30	11	19	11	

Table 6. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
10-Nov-91	56.3	16.70	11	7	11	
11-Nov-91	57.0	24.40	11	21	40	
				2,375	1,626	

Table 7. Daily counts and environmental information, Cowichan River enumeration fence, 1992.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
18-Aug-92	20.0	4.53	22	0	0	
19-Aug-92	20.8	4.50	21	1	1	
20-Aug-92	20.3	4.35	19	0	0	
21-Aug-92	13.7	4.27	20	0	2	
22-Aug-92	19.8	4.25	19	1	1	
23-Aug-92	19.3	4.08	20	0	1	
24-Aug-92	19.1	4.05	20	1	1	
25-Aug-92	21.0	4.73	18	0	7	
26-Aug-92	20.1	4.41	20	1	1	
27-Aug-92	20.0	4.33	20	0	3	
28-Aug-92	19.5	4.16	19	1	6	
29-Aug-92	20.0	4.17	19	3	4	
30-Aug-92	19.4	4.32	19	3	2	
31-Aug-92	21.0	4.70	19	2	1	
01-Sep-92	21.0	4.68	19	16	9	
02-Sep-92	24.9	4.60	18	29	10	
03-Sep-92	24.9	4.53	18	61	11	
04-Sep-92	20.8	4.55	18	4	6	
05-Sep-92	19.1	4.43	18	6	2	
06-Sep-92	23.1	4.93	15	43	5	
07-Sep-92	20.0	4.78	15	3	1	Estimated discharge.
08-Sep-92	21.0	4.95	17	5	3	Estimated discharge.
09-Sep-92	20.8	4.88	17	4	3	Estimated discharge.
10-Sep-92	0.0	4.93	17	0	2	Estimated discharge.
11-Sep-92	21.7	5.13	16	29	20	Estimated discharge.
12-Sep-92	22.0	5.21	17	0	1	Estimated discharge.
13-Sep-92	20.0	4.90	16	3	4	Estimated discharge.
14-Sep-92	20.1	4.55	15	1	5	Estimated discharge.

Table 7. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
15-Sep-92	20.1	4.47	14	7	8	Estimated discharge.
16-Sep-92	20.3	4.58	13	2	9	Estimated discharge.
17-Sep-92	20.2	4.75	14	3	9	Estimated discharge.
18-Sep-92	21.0	4.80	14	0	8	Estimated discharge.
19-Sep-92	20.8	4.80	15	2	7	Estimated discharge.
20-Sep-92	20.9	4.70	17	3	13	Estimated discharge.
21-Sep-92	21.4	4.58	17	7	20	Estimated discharge.
22-Sep-92	21.3	4.47	17	30	11	Estimated discharge.
23-Sep-92	22.0	4.85	17	45	6	Estimated discharge.
24-Sep-92	22.6	4.80	16	59	59	Estimated discharge.
25-Sep-92	21.9	4.65	15	19	10	Estimated discharge.
26-Sep-92	21.8	5.50	16	20	13	Estimated discharge.
27-Sep-92	22.1	7.60	14	14	8	Est. discharge. Water release commenced.
28-Sep-92	30.6	10.20	14	142	33	Estimated discharge.
29-Sep-92	30.8	12.00	13	153	39	Estimated discharge.
30-Sep-92	35.1	12.20	16	55	19	Estimated discharge.
01-Oct-92	32.1	12.20	20	179	17	Estimated discharge.
02-Oct-92	35.7	12.30	17	55	9	Estimated discharge.
03-Oct-92	31.3	12.50	15	90	16	Estimated discharge.
04-Oct-92	35.6	11.30	15	132	3	Estimated discharge.
05-Oct-92	34.6	9.20	14	317	10	Est. discharge. Water release terminated.
06-Oct-92	30.0	7.24	13	23	2	Estimated discharge.
07-Oct-92	23.9	5.24	13	40	0	
08-Oct-92	26.8	5.45	14	13	8	
09-Oct-92	24.6	5.68	13	30	3	
10-Oct-92	24.7	5.62	13	14	7	
11-Oct-92	25.0	5.66	14	88	26	
12-Oct-92	24.9	5.61	17	28	11	
13-Oct-92	24.9	5.60	12	38	4	
14-Oct-92	23.7	5.21	11	10	7	
15-Oct-92	22.6	5.19	8	10	8	
16-Oct-92	23.1	5.63	10	23	16	
17-Oct-92	24.2	5.30	11	53	24	
18-Oct-92	26.3	7.00	12	123	60	
19-Oct-92	28.9	7.47	11	956	574	
20-Oct-92	26.2	8.53	12	1,032	930	
21-Oct-92	35.2	11.20	12	530	360	
22-Oct-92	39.1	14.90	11	89	57	
23-Oct-92	49.3	22.70	12	1,251	632	
24-Oct-92	53.2	26.30	11	486	164	
25-Oct-92	52.2	25.60	12	790	177	
26-Oct-92	52.4	27.10	11	40	32	

Table 7. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
27-Oct-92	56.5	30.30	11	157	73	
28-Oct-92	55.7	29.60	12	148	16	
29-Oct-92	55.8	28.80	12	109	47	
30-Oct-92	55.5	29.20	11	108	17	
31-Oct-92	56.0	34.60	12	0	0	
				7,740	3,694	

Table 8. Daily counts and environmental information, Cowichan River enumeration fence, 1993.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
23-Aug-93	25.0	5.75	18	2	0	
24-Aug-93	24.6	5.55	17	5	14	
25-Aug-93	24.1	5.41	17	6	19	
26-Aug-93	25.3	5.25	18	1	1	
27-Aug-93	26.8	5.31	18	1	3	
28-Aug-93	27.1	5.26	18	2	4	
29-Aug-93	26.2	5.06	18	0	15	
30-Aug-93	25.9	5.04	17	2	12	
31-Aug-93	27.0	5.34	17	1	22	
01-Sep-93	26.4	5.13	17	0	17	
02-Sep-93	25.3	5.04	18	1	10	
03-Sep-93	26.0	5.03	19	1	8	
04-Sep-93	26.3	5.11	19	0	10	
05-Sep-93	26.0	5.14	19	1	14	
06-Sep-93	25.9	5.03	19	6	23	
07-Sep-93	26.6	5.17	19	1	45	
08-Sep-93	26.5	5.11	19	1	21	
09-Sep-93	25.9	5.17	18	3	22	
10-Sep-93	25.8	5.19	18	1	5	
11-Sep-93	26.0	5.17	18	6	6	
12-Sep-93	26.0	5.10	17	4	7	
13-Sep-93	26.0	5.06	17	3	13	
14-Sep-93	26.3	5.27	17	4	8	
15-Sep-93	26.0	5.33	16	15	21	
16-Sep-93	26.2	5.31	17	2	4	

Table 8. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
17-Sep-93	25.9	5.35	16	10	20	
18-Sep-93	25.9	5.19	15	6	19	
19-Sep-93	26.0	5.24	16	0	2	
20-Sep-93	26.4	5.48	16	32	10	
21-Sep-93	26.1	5.39	16	31	10	
22-Sep-93	25.8	5.36	14	7	2	
23-Sep-93	25.8	5.47	14	11	8	
24-Sep-93	26.5	5.62	14	10	2	
25-Sep-93	26.0	5.49	14	6	7	
26-Sep-93	25.7	6.30	14	5	10	Water release commenced.
27-Sep-93	38.2	14.60	14	105	484	
28-Sep-93	42.3	14.30	15	9	9	
29-Sep-93	41.5	13.60	16	28	30	
30-Sep-93	40.3	12.80	15	35	7	Water release terminated.
01-Oct-93	38.3	11.40	15	55	3	
02-Oct-93	32.1	5.35	15	55	14	
03-Oct-93	25.0	4.89	14	13	5	
04-Oct-93	25.5	5.18	15	13	1	
05-Oct-93	25.2	5.43	15	23	6	
06-Oct-93	25.4	5.50	15	377	320	
07-Oct-93	25.1	5.43	14	65	28	
08-Oct-93	24.8	5.35	13	23	3	
09-Oct-93	21.1	5.27	13	14	1	
10-Oct-93	25.8	5.65	11	28	0	
11-Oct-93	25.1	5.52	12	80	23	
12-Oct-93	24.7	5.51	14	637	344	
13-Oct-93	25.1	5.38	14	354	555	
14-Oct-93	25.1	5.30	14	61	38	
15-Oct-93	25.8	5.42	14	46	36	
16-Oct-93	25.5	5.27	13	23	15	
17-Oct-93	26.1	5.47	13	56	82	
18-Oct-93	25.5	5.44	12	115	148	
19-Oct-93	25.5	5.63	13	86	44	
20-Oct-93	25.7	5.93	11	57	64	
21-Oct-93	24.7	5.59	13	100	208	
22-Oct-93	26.3	6.27	13	501	617	
23-Oct-93	29.1	7.94	13	535	789	
24-Oct-93	35.0	9.89	12	538	611	
25-Oct-93	33.3	8.90	12	25	65	
26-Oct-93	33.0	8.61	11	11	39	
27-Oct-93	32.2	8.37	11	18	26	
28-Oct-93	34.1	10.20	12	11	28	

Table 8. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
29-Oct-93	40.6	13.30	13	49	41	
30-Oct-93	40.6	12.80	12	36	29	
31-Oct-93	39.8	12.20	12	18	23	
01-Nov-93	39.6	12.20	10	22	28	
02-Nov-93	38.6	12.40	12	14	34	
03-Nov-93	39.8	14.10	12	18	33	
04-Nov-93	40.0	13.80	10	4	3	
05-Nov-93	40.0	13.30	10	108	15	
06-Nov-93	40.0	12.90	11	5	13	
07-Nov-93	39.0	12.60	11	13	7	
08-Nov-93	40.0	12.30	10	13	23	
09-Nov-93	39.3	12.00	10	18	13	
10-Nov-93	37.6	11.60	10	6	13	
11-Nov-93	36.3	11.10	9	11	12	
12-Nov-93	36.6	10.20	9	2	7	
13-Nov-93	35.0	10.00	9	1	12	
14-Nov-93	34.6	9.50	9	392	281	
15-Nov-93	34.6	9.34	10	28	83	
16-Nov-93	35.0	9.36	9	4	9	
17-Nov-93	35.3	9.51	9	4	12	
18-Nov-93	36.3	10.00	9	2	0	
19-Nov-93	34.3	10.20	9	3	7	
20-Nov-93	34.3	10.30	9	1	11	
21-Nov-93	40.0	10.70	13	0	0	
22-Nov-93	43.0	10.80	7	2	2	
				5,058	5,768	

Table 9. Daily counts and environmental information, Cowichan River enumeration fence, 1994.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
15-Aug-94	19.0	5.48	19	0	2	
16-Aug-94	19.0	5.50	19	0	3	
17-Aug-94	19.0	5.33	18	0	3	
18-Aug-94	20.3	5.26	N/A	2	5	
19-Aug-94	20.0	5.39	19	1	20	

Table 9. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
20-Aug-94	19.8	4.82	20	4	7	
21-Aug-94	19.3	4.80	18	1	10	
22-Aug-94	19.3	5.02	19	0	13	
23-Aug-94	21.6	5.55	18	0	16	
24-Aug-94	20.6	5.32	19	2	22	
25-Aug-94	20.6	5.23	17	1	25	
26-Aug-94	20.1	5.13	18	4	37	
27-Aug-94	20.0	5.04	19	2	11	
28-Aug-94	20.0	4.90	19	8	16	
29-Aug-94	19.8	4.96	19	0	5	
30-Aug-94	19.6	5.16	19	0	9	
31-Aug-94	19.6	5.17	19	4	14	
01-Sep-94	19.2	5.06	18	4	27	
02-Sep-94	19.5	4.97	19	6	14	
03-Sep-94	18.1	5.26	17	3	28	
04-Sep-94	18.0	5.13	17	9	25	
05-Sep-94	18.6	5.06	18	9	51	
06-Sep-94	20.0	5.53	18	8	57	
07-Sep-94	20.0	5.55	18	1	7	
08-Sep-94	20.1	5.67	18	4	17	
09-Sep-94	21.5	5.95	18	13	54	
10-Sep-94	22.3	6.11	17	57	541	
11-Sep-94	21.3	5.78	17	2	16	
12-Sep-94	19.9	5.58	17	45	122	
13-Sep-94	19.5	5.42	17	45	155	
14-Sep-94	20.0	5.55	17	5	20	
15-Sep-94	19.6	5.49	17	9	12	
16-Sep-94	19.3	5.41	18	23	45	
17-Sep-94	19.0	5.24	18	15	58	
18-Sep-94	19.6	5.23	18	19	52	
19-Sep-94	19.6	5.29	18	137	1,117	
20-Sep-94	19.2	5.24	17	196	759	
21-Sep-94	19.2	5.21	18	51	125	
22-Sep-94	18.8	5.10	19	12	64	
23-Sep-94	18.7	5.03	17	14	127	
24-Sep-94	19.1	5.04	18	67	502	
25-Sep-94	18.7	4.97	18	30	299	
26-Sep-94	18.9	4.94	17	28	218	
27-Sep-94	19.3	5.27	17	96	323	
28-Sep-94	19.3	5.37	16	71	119	
29-Sep-94	19.1	5.31	17	31	47	
30-Sep-94	19.1	5.11	17	8	18	

Table 9. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
01-Oct-94	19.6	5.34	16	3	19	
02-Oct-94	19.3	5.37	15	51	212	
03-Oct-94	19.6	5.14	13	143	268	
04-Oct-94	19.3	5.23	12	21	41	
05-Oct-94	19.6	6.81	14	88	373	Water release commenced.
06-Oct-94	28.7	13.20	14	1,676	4,358	
07-Oct-94	27.2	12.60	14	177	202	
08-Oct-94	26.3	11.80	14	42	65	Water release terminated.
09-Oct-94	24.6	6.48	14	10	6	
10-Oct-94	14.9	5.59	14	9	5	
11-Oct-94	14.5	5.40	13	45	64	
12-Oct-94	19.6	5.37	12	24	45	
13-Oct-94	19.4	5.40	11	21	30	
14-Oct-94	20.0	5.75	11	54	149	
15-Oct-94	19.7	5.45	11	36	43	
16-Oct-94	19.3	5.16	11	83	57	Estimated discharge
17-Oct-94	19.2	9.70	11	25	36	Est. discharge. Water release commenced.
18-Oct-94	24.8	11.90	11	292	330	Estimated discharge
19-Oct-94	29.1	9.00	11	62	59	Estimated discharge
20-Oct-94	29.2	7.30	11	34	110	Est. discharge. Water release terminated.
21-Oct-94	25.7	7.10	11	44	138	Estimated discharge
22-Oct-94	22.5	7.20	10	17	28	Estimated discharge
23-Oct-94	21.0	7.25	11	8	12	Estimated discharge
24-Oct-94	21.1	7.55	10	12	72	Estimated discharge
25-Oct-94	22.6	8.23	10	35	73	Estimated discharge
26-Oct-94	26.9	10.80	10	375	669	Estimated discharge
27-Oct-94	40.4	16.70	11	295	305	Estimated discharge
28-Oct-94	48.0	20.90	10	256	240	Estimated discharge
29-Oct-94	48.1	19.90	10	16	35	
30-Oct-94	48.0	21.40	11	24	50	
31-Oct-94	58.1	25.30	11	4	17	Estimated discharge
01-Nov-94	64.8	39.00	10	2	12	Estimated discharge
02-Nov-94	64.2	37.80	9	4	7	Estimated discharge
03-Nov-94	64.2	38.20	10	5	2	Estimated discharge
04-Nov-94	65.8	38.00	9	0	0	Estimated discharge
05-Nov-94	65.8	38.70	10	5	4	Estimated discharge
06-Nov-94	64.7	38.80	10	0	1	Estimated discharge
07-Nov-94	68.1	39.50	10	3	6	Estimated discharge
08-Nov-94	70.0	42.00	10	1	0	Estimated discharge
09-Nov-94	78.0	44.00	10	0	0	Estimated discharge
10-Nov-94	82.0	45.30	10	0	0	Estimated discharge

Table 9. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
11-Nov-94	92.2	46.20	10	0	1	Estimated discharge
12-Nov-94	0.0	48.50	N/A	N/A	N/A	Estimated discharge
13-Nov-94	92.0	52.00	10	1	0	Estimated discharge
				5,050	13,381	

Table 10. Daily counts and environmental information, Cowichan River enumeration fence, 1995.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
08-Sep-95	30.0	6.23	17	17	22	
09-Sep-95	34.8	5.89	17	6	78	
10-Sep-95	36.5	5.86	17	33	99	
11-Sep-95	42.8	5.92	17	110	269	
12-Sep-95	42.6	6.05	19	57	198	
13-Sep-95	42.0	6.06	19	31	84	
14-Sep-95	42.6	6.25	19	28	71	
15-Sep-95	43.0	6.02	19	18	53	
16-Sep-95	43.5	5.89	19	13	29	
17-Sep-95	42.1	6.16	18	10	33	
18-Sep-95	42.9	5.94	18	23	65	
19-Sep-95	42.5	5.83	18	291	465	
20-Sep-95	42.7	5.84	20	19	50	
21-Sep-95	42.7	5.79	19	64	57	
22-Sep-95	44.5	6.15	17	129	209	24 hour water release.
23-Sep-95	45.0	7.09	16	59	140	
24-Sep-95	41.8	5.73	16	16	28	
25-Sep-95	42.0	5.74	17	150	139	
26-Sep-95	42.5	5.92	17	1,269	932	
27-Sep-95	42.8	5.60	16	119	55	
28-Sep-95	42.7	5.18	16	676	360	
29-Sep-95	42.5	4.84	16	396	237	
30-Sep-95	43.8	5.32	14	253	175	
01-Oct-95	43.0	5.16	15	63	39	
02-Oct-95	43.0	5.41	15	159	65	
03-Oct-95	43.0	5.41	14	241	130	
04-Oct-95	43.5	5.10	14	29	29	

Table 10. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
05-Oct-95	42.7	4.93	15	160	76	
06-Oct-95	43.1	5.46	14	127	86	
07-Oct-95	43.5	5.53	15	226	126	
08-Oct-95	43.5	5.76	14	191	226	
09-Oct-95	43.6	6.23	14	444	379	
10-Oct-95	45.2	9.23	14	2,600	1,913	
11-Oct-95	49.4	9.17	12	867	358	
12-Oct-95	52.5	9.72	12	277	125	
13-Oct-95	54.8	9.89	14	142	76	
14-Oct-95	55.1	12.90	13	118	53	
15-Oct-95	55.1	16.00	15	121	18	
16-Oct-95	58.3	21.10	14	607	135	
17-Oct-95	61.0	30.30	15	542	211	
18-Oct-95	65.1	35.70	16	8	1	
19-Oct-95	74.8	39.10	14	6	9	
				10,715	7,903	

Table 11. Daily counts and environmental information, Cowichan River enumeration fence, 1996.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
30-Aug-96	49.0	4.77	21	3	7	
31-Aug-96	42.0	4.78	20	3	9	
01-Sep-96	47.0	4.94	19	23	20	
02-Sep-96	44.0	5.21	19	4	3	
03-Sep-96	49.0	5.30	18	14	3	
04-Sep-96	49.0	5.12	18	34	133	
05-Sep-96	48.0	5.09	16	7	15	
06-Sep-96	47.0	4.80	18	16	8	
07-Sep-96	47.0	4.72	17	28	41	
08-Sep-96	48.0	4.83	17	7	17	
09-Sep-96	49.0	4.88	17	224	191	
10-Sep-96	48.0	4.84	17	31	25	
11-Sep-96	47.0	4.86	17	29	24	
12-Sep-96	49.0	4.85	18	3	10	
13-Sep-96	49.0	4.82	16	12	20	

Table 11. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
14-Sep-96	49.0	4.95	16	141	155	
15-Sep-96	49.0	4.90	18	247	233	
16-Sep-96	49.0	4.91	17	822	376	
17-Sep-96	50.0	4.99	16	90	34	
18-Sep-96	49.0	4.96	16	9	7	
19-Sep-96	50.0	4.94	16	36	29	
20-Sep-96	49.0	4.99	15	52	16	
21-Sep-96	50.0	5.00	14	35	15	
22-Sep-96	50.0	4.92	14	27	16	
23-Sep-96	49.0	4.93	13	64	40	
24-Sep-96	49.0	4.95	14	110	23	
25-Sep-96	49.0	4.95	13	14	8	
26-Sep-96	49.0	4.95	14	20	9	
27-Sep-96	48.0	5.06	14	346	469	
28-Sep-96	49.0	5.09	14	332	109	
29-Sep-96	49.0	5.02	14	446	261	
30-Sep-96	49.0	4.95	15	1,111	585	
01-Oct-96	49.0	4.88	15	1,208	366	
02-Oct-96	48.0	4.90	14	211	87	
03-Oct-96	49.0	5.08	14	898	448	
04-Oct-96	53.0	5.91	15	769	743	
05-Oct-96	54.0	6.09	14	345	138	
06-Oct-96	54.0	5.81	14	58	14	
07-Oct-96	53.0	5.63	15	228	60	
08-Oct-96	54.0	5.51	14	115	35	
09-Oct-96	53.0	5.45	14	53	16	
10-Oct-96	52.0	5.44	14	35	17	
11-Oct-96	52.0	5.69	15	145	100	
12-Oct-96	51.0	5.87	14	140	41	
13-Oct-96	58.0	8.13	13	549	300	
14-Oct-96	67.0	10.60	13	481	167	
15-Oct-96	67.0	11.80	13	479	213	
16-Oct-96	67.0	11.20	13	40	25	
17-Oct-96	67.0	15.50	12	48	16	
18-Oct-96	68.0	39.60	11	88	23	
19-Oct-96	70.0	35.40	11	39	13	
20-Oct-96	80.0	31.60	11	17	4	
21-Oct-96	90.0	35.60	13	14	5	
22-Oct-96	95.0	53.00	13	15	1	
23-Oct-96	98.0	52.80	12	67	9	
24-Oct-96	99.0	62.10	11	3	0	
				10,385	5,752	

Table 12. Daily counts and environmental information, Cowichan River enumeration fence, 1997.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
05-Sep-97	32.0	8.66	N/A	0	0	
06-Sep-97	31.5	8.48	N/A	0	1	
07-Sep-97	29.0	8.37	N/A	5	5	
08-Sep-97	32.7	8.26	N/A	19	34	
09-Sep-97	32.0	8.09	N/A	13	19	
10-Sep-97	31.3	8.01	N/A	14	17	
11-Sep-97	31.7	8.01	19.0	6	36	
12-Sep-97	32.0	7.90	15.3	30	66	
13-Sep-97	31.0	7.83	17.3	12	28	
14-Sep-97	32.7	8.73	18.3	22	26	
15-Sep-97	32.3	8.94	17.3	31	14	
16-Sep-97	33.7	9.89	15.0	48	39	
17-Sep-97	41.0	16.50	16.7	135	58	Water release commenced.
18-Sep-97	53.3	25.00	17.3	619	184	
19-Sep-97	57.0	28.00	17.3	807	453	
20-Sep-97	55.3	26.90	14.5	104	93	
21-Sep-97	60.3	26.40	16.0	395	201	
22-Sep-97	57.3	26.00	15.3	157	117	
23-Sep-97	59.0	25.90	18.0	84	67	
24-Sep-97	58.7	25.90	17.0	159	131	
25-Sep-97	59.0	28.30	17.0	32	26	Increased river discharge.
26-Sep-97	65.3	35.40	16.0	1,028	329	
27-Sep-97	76.0	40.90	16.0	120	146	
28-Sep-97	82.0	47.10	17.0	381	241	
29-Sep-97	85.0	49.40	16.3	9	12	Water release terminated.
30-Sep-97	88.7	57.70	16.0	97	23	
01-Oct-97	100.3	73.10	15.7	78	8	
02-Oct-97	122.0	92.30	15.7	0	2	
03-Oct-97	128.0	119.00	15.3	0	0	
				4,405	2,376	

Table 13. Daily counts and environmental information, Cowichan River enumeration fence, 1998.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
05-Sep-98	38.0	3.98	18.0	0	0	
06-Sep-98	39.0	3.98	19.0	1	0	
07-Sep-98	38.7	4.04	18.3	0	12	
08-Sep-98	38.2	4.24	18.3	3	21	
09-Sep-98	38.2	4.21	18.3	3	10	
10-Sep-98	38.2	4.15	19.0	5	14	
11-Sep-98	37.7	4.33	19.0	1	2	
12-Sep-98	37.2	4.09	18.3	2	8	
13-Sep-98	37.3	4.02	19.3	5	21	
14-Sep-98	37.7	4.19	19.0	5	9	
15-Sep-98	38.0	4.31	18.7	8	11	
16-Sep-98	38.0	4.24	18.3	1	4	
17-Sep-98	38.0	4.12	18.3	2	4	
18-Sep-98	38.3	4.22	18.0	1	5	
19-Sep-98	38.4	4.25	17.3	17	30	
20-Sep-98	37.9	4.13	15.3	9	27	
21-Sep-98	37.5	3.96	17.7	12	20	
22-Sep-98	41.0	4.04	17.7	35	93	
23-Sep-98	41.0	4.11	16.0	12	34	
24-Sep-98	40.8	4.18	17.0	12	39	
25-Sep-98	40.7	4.27	16.7	9	41	
26-Sep-98	40.6	4.28	17.0	7	13	
27-Sep-98	40.4	4.25	17.3	10	15	
28-Sep-98	40.0	4.24	16.0	12	30	
29-Sep-98	40.0	4.21	15.7	6	27	
30-Sep-98	39.7	4.30	15.7	7	12	
01-Oct-98	40.5	4.37	15.7	16	21	
02-Oct-98	40.7	4.51	15.7	4	4	
03-Oct-98	44.8	5.28	14.3	7	18	
04-Oct-98	44.3	5.56	14.7	9	8	
05-Oct-98	43.0	5.38	15.3	24	23	
06-Oct-98	43.0	5.11	14.7	178	217	
07-Oct-98	43.4	4.96	14.7	36	21	
08-Oct-98	44.5	5.00	14.3	10	13	
09-Oct-98	43.5	5.59	14.0	14	22	
10-Oct-98	45.1	5.86	13.0	30	39	
11-Oct-98	45.3	5.73	13.7	39	34	
12-Oct-98	48.7	7.61	13.7	64	72	
13-Oct-98	55.0	10.30	14.7	783	752	
14-Oct-98	57.3	12.00	12.7	138	99	
15-Oct-98	59.3	12.40	13.3	60	24	
16-Oct-98	58.0	12.30	12.7	63	15	

Table 13. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
17-Oct-98	58.5	13.00	13.3	60	78	
18-Oct-98	61.9	14.40	12.7	105	33	
19-Oct-98	60.0	14.40	12.0	51	22	
20-Oct-98	60.0	14.60	11.7	18	14	
21-Oct-98	60.0	14.50	10.3	19	9	
22-Oct-98	60.0	14.40	12.3	68	32	
23-Oct-98	60.0	14.00	12.0	84	65	
24-Oct-98	60.0	13.50	11.0	39	29	
25-Oct-98	60.2	13.20	11.7	19	13	
26-Oct-98	60.0	12.90	13.3	21	22	
27-Oct-98	61.3	12.90	13.0	169	61	
28-Oct-98	65.7	12.50	12.3	57	17	
29-Oct-98	51.2	11.90	12.0	28	16	
30-Oct-98	56.3	11.50	11.0	26	26	
31-Oct-98	63.0	11.60	12.3	40	10	
01-Nov-98	63.1	11.90	12.0	56	95	
02-Nov-98	58.0	12.90	12.0	234	109	
03-Nov-98	59.7	13.80	12.0	208	75	
04-Nov-98	61.2	14.30	12.0	306	166	
05-Nov-98	65.5	16.10	12.0	501	168	
06-Nov-98	64.5	15.80	11.0	539	74	
07-Nov-98	52.9	15.30	10.0	16	41	
08-Nov-98	65.1	14.90	10.5	4	6	
				4,328	3,065	

Table 14. Daily counts and environmental information, Cowichan River enumeration fence, 1999.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
27-Aug-99	N/A	8.09	20.0	2	1	
28-Aug-99	N/A	7.96	19.3	5	2	
29-Aug-99	44.5	7.82	19.0	0	0	
30-Aug-99	44.8	7.57	17.3	6	9	
31-Aug-99	44.0	7.49	17.0	3	2	
01-Sep-99	43.5	7.3	18.7	7	1	
02-Sep-99	44.5	7.11	18.7	5	5	

Table 14. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
03-Sep-99	44.1	6.92	17.3	3	3	
04-Sep-99	44.8	6.75	18.0	2	2	
05-Sep-99	42.8	6.73	18.0	1	0	
06-Sep-99	42.8	6.81	17.3	1	1	
07-Sep-99	43.3	6.64	18.5	3	2	
08-Sep-99	42.7	6.42	17.3	6	3	
09-Sep-99	44.0	6.31	18.0	2	4	
10-Sep-99	43.7	6.28	17.0	5	2	
11-Sep-99	44.0	6.51	17.0	10	12	
12-Sep-99	44.2	6.23	17.3	2	14	
13-Sep-99	41.5	6.2	17.3	0	10	
14-Sep-99	42.4	6.51	17.7	1	3	
15-Sep-99	42.7	6.35	17.0	22	30	
16-Sep-99	42.3	6.13	17.3	34	11	
17-Sep-99	40.0	6.01	16.3	23	5	
18-Sep-99	40.0	6.22	16.7	10	19	
19-Sep-99	41.7	6.95	17.0	8	9	
20-Sep-99	41.1	6.43	17.0	9	7	
21-Sep-99	40.0	6.09	16.3	28	37	
22-Sep-99	40.5	6.27	18.0	13	9	
23-Sep-99	40.8	6.59	17.3	9	19	
24-Sep-99	42.1	6.38	16.3	3	3	
25-Sep-99	42.2	6.79	15.3	51	28	
26-Sep-99	40.0	6.38	9.3	72	34	
27-Sep-99	40.4	6.29	14.0	25	12	
28-Sep-99	40.7	6.39	13.0	39	20	
29-Sep-99	40.7	6.55	14.3	79	61	
30-Sep-99	40.7	6.48	14.3	50	19	
01-Oct-99	40.7	6.38	13.3	91	43	
02-Oct-99	40.3	6.28	11.7	37	20	
03-Oct-99	40.7	6.65	13.0	28	12	
04-Oct-99	40.7	6.41	12.7	48	19	
05-Oct-99	40.8	6.56	13.7	48	34	
06-Oct-99	41.3	6.68	13.3	35	19	
07-Oct-99	48.9	9.21	13.3	133	88	Water release commenced.
08-Oct-99	57.7	18.0	14.7	553	120	
09-Oct-99	57.1	18.2	14.0	544	77	
10-Oct-99	53.7	18.0	12.7	55	19	
11-Oct-99	55.0	17.9	13.3	45	11	
12-Oct-99	55.8	17.8	12.3	67	17	
13-Oct-99	55.9	19.0	15.0	287	67	
14-Oct-99	55.9	18.7	13.3	194	50	

Table 14. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
15-Oct-99	55.6	17.9	13.0	72	12	
16-Oct-99	55.7	17.3	12.0	29	9	Water release terminated.
17-Oct-99	54.8	16.6	12.7	45	5	
18-Oct-99	55.4	16.0	12.3	91	25	
19-Oct-99	55.2	15.6	13.0	41	9	
20-Oct-99	55.1	15.1	14.0	41	19	
21-Oct-99	55.0	14.7	12.3	14	6	
22-Oct-99	55.0	14.3	12.3	19	10	
23-Oct-99	55.4	14.0	12.3	18	20	
24-Oct-99	55.0	14.0	12.3	35	8	
25-Oct-99	54.0	13.5	12.7	45	9	
26-Oct-99	53.8	13.3	11.7	34	8	
27-Oct-99	53.0	13.0	11.3	43	7	
28-Oct-99	54.6	17.2	12.3	416	94	
29-Oct-99	57.3	22.0	12.0	120	39	
30-Oct-99	92.5	37.5	12.0	57	16	
				3,824	1,291	

Table 15. Daily counts and environmental information, Cowichan River enumeration fence, 2000.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
08-Sep-00	46.0	5.94	17.0	1	0	
09-Sep-00	45.0	5.92	17.0	0	0	
10-Sep-00	46.0	6.00	16.0	0	0	
11-Sep-00	45.0	6.00	16.0	8	2	
12-Sep-00	45.0	5.72	16.7	17	4	
13-Sep-00	45.7	5.61	16.3	7	4	
14-Sep-00	45.0	5.68	17.3	2	7	
15-Sep-00	45.0	6.26	18.0	5	20	
16-Sep-00	45.0	6.21	17.7	6	8	
17-Sep-00	45.0	6.11	19.0	11	10	
18-Sep-00	45.3	6.04	18.0	9	4	
19-Sep-00	45.0	6.00	18.3	119	97	
20-Sep-00	45.0	5.97	18.3	72	49	
21-Sep-00	45.0	6.01	17.7	18	13	

Table 15. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
22-Sep-00	45.0	6.27	16.3	35	40	
23-Sep-00	44.7	6.24	14.7	19	8	
24-Sep-00	45.0	6.12	15.0	7	4	
25-Sep-00	48.3	7.06	15.0	5	10	Water release commenced.
26-Sep-00	55.7	11.80	15.7	236	84	
27-Sep-00	64.0	16.70	17.0	811	135	
28-Sep-00	63.3	16.70	15.0	241	77	
29-Sep-00	63.3	17.50	17.0	354	96	
30-Sep-00	64.3	17.30	16.7	480	116	
01-Oct-00	63.3	16.70	16.0	226	31	
02-Oct-00	61.3	15.60	16.0	207	47	Water release terminated.
03-Oct-00	55.3	11.80	15.0	24	7	
04-Oct-00	50.7	9.02	14.3	25	13	
05-Oct-00	50.7	9.18	13.7	34	8	
06-Oct-00	53.0	10.40	12.7	35	36	
07-Oct-00	53.7	11.20	12.7	54	13	
08-Oct-00	52.0	10.30	15.0	6	7	
09-Oct-00	50.3	9.31	15.0	16	18	
10-Oct-00	51.0	9.70	15.0	112	61	
11-Oct-00	50.7	9.37	13.3	17	16	
12-Oct-00	50.0	9.26	13.3	13	6	
13-Oct-00	50.3	9.47	14.7	16	10	
14-Oct-00	50.0	9.35	13.7	10	4	
15-Oct-00	50.0	9.36	13.0	5	1	
16-Oct-00	51.7	10.60	13.3	26	14	
17-Oct-00	57.3	14.40	13.0	746	196	
18-Oct-00	63.0	18.50	12.8	253	48	
19-Oct-00	63.0	20.00	13.0	60	14	
20-Oct-00	83.7	39.40	13.0	208	30	
21-Oct-00	82.7	38.90	12.3	55	11	
22-Oct-00	82.3	38.50	12.3	32	4	
23-Oct-00	81.7	37.80	13.0	15	4	
24-Oct-00	77.5	28.30	13.0	9	4	
				4,667	1,391	

Table 16. Daily counts and environmental information, Cowichan River enumeration fence, 2001.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
04-Sep-01	60.0	7.00	18.0	0	0	
05-Sep-01	53.3	6.40	16.9	0	0	
06-Sep-01	43.7	6.06	17.0	1	0	
07-Sep-01	43.7	5.89	16.1	4	0	
08-Sep-01	43.7	5.82	16.7	1	0	
09-Sep-01	43.6	5.70	16.8	9	3	
10-Sep-01	43.3	5.70	17.2	3	7	
11-Sep-01	43.0	5.63	17.0	1	0	
12-Sep-01	43.8	5.65	17.9	3	2	
13-Sep-01	43.7	5.60	18.3	4	5	
14-Sep-01	43.7	5.55	18.4	21	1	
15-Sep-01	43.3	5.40	18.4	3	1	
16-Sep-01	43.0	5.38	18.9	8	5	
17-Sep-01	43.0	5.33	18.3	25	13	
18-Sep-01	42.7	5.39	17.6	5	5	
19-Sep-01	42.7	5.48	17.0	13	5	
20-Sep-01	42.7	5.57	17.0	9	6	
21-Sep-01	43.8	5.70	17.2	41	28	
22-Sep-01	45.0	5.61	17.2	44	41	
23-Sep-01	45.0	5.56	17.8	41	12	
24-Sep-01	45.0	5.35	18.7	113	46	
25-Sep-01	45.1	5.61	18.3	32	30	
26-Sep-01	46.0	6.10	18.1	38	40	
27-Sep-01	47.3	9.07	15.3	47	25	Water release commenced.
28-Sep-01	62.4	15.90	16.0	612	418	
29-Sep-01	62.7	16.20	16.0	139	96	
30-Sep-01	63.0	16.30	16.1	35	15	
01-Oct-01	61.8	15.40	15.9	168	31	
02-Oct-01	59.4	13.90	15.4	28	3	
03-Oct-01	54.1	11.20	15.7	15	2	Water release terminated.
04-Oct-01	50.8	9.18	15.5	38	6	
05-Oct-01	49.6	9.10	13.5	13	1	
06-Oct-01	49.8	9.22	14.5	3	0	
07-Oct-01	49.7	9.09	14.1	13	1	
08-Oct-01	49.6	9.42	14.3	16	1	
09-Oct-01	49.3	9.19	13.7	96	5	
10-Oct-01	49.4	9.53	14.0	124	8	
11-Oct-01	50.0	9.82	13.7	79	6	
12-Oct-01	51.3	12.50	14.0	149	17	
13-Oct-01	62.8	18.00	14.0	660	151	
14-Oct-01	63.6	18.00	14.0	104	26	
15-Oct-01	63.0	18.00	13.7	56	8	

Table 16. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
16-Oct-01	62.1	17.60	13.3	9	13	
17-Oct-01	59.1	15.80	12.9	8	1	
18-Oct-01	56.2	13.80	13.0	17	10	
19-Oct-01	52.0	11.00	13.8	6	10	
20-Oct-01	50.8	10.90	12.6	6	2	
21-Oct-01	50.6	11.20	12.3	12	3	
22-Oct-01	52.1	12.10	12.0	9	4	
23-Oct-01	59.7	17.80	11.6	56	11	
24-Oct-01	65.3	21.60	10.4	69	36	
25-Oct-01	69.4	24.90	10.1	122	77	
26-Oct-01	75.0	29.80	9.0	77	57	
27-Oct-01	79.4	35.20	9.0	37	42	
28-Oct-01	83.1	37.90	N/A	15	13	
29-Oct-01	84.0	39.10	N/A	17	10	
30-Oct-01	87.3	41.30	N/A	39	37	
31-Oct-01	88.5	45.30	N/A	48	56	
				3,361	1,452	

Table 17. Daily counts and environmental information, Cowichan River enumeration fence, 2002.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
03-Sep-02	N/A	5.59	18.0	0	0	
04-Sep-02	51.0	5.95	17.5	1	1	
05-Sep-02	51.0	5.80	16.0	2	0	
06-Sep-02	50.3	5.80	16.3	0	1	
07-Sep-02	50.3	6.05	16.0	1	0	
08-Sep-02	50.0	5.98	16.3	0	1	
09-Sep-02	50.0	5.94	16.7	0	0	
10-Sep-02	52.7	6.32	17.0	6	4	
11-Sep-02	54.0	6.77	18.3	25	14	
12-Sep-02	53.0	6.38	16.7	21	9	
13-Sep-02	53.7	6.19	15.7	69	24	
14-Sep-02	53.0	5.92	18.3	38	21	
15-Sep-02	53.0	5.92	18.0	15	15	
16-Sep-02	53.3	6.27	16.7	19	33	

Table 17. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
17-Sep-02	53.0	6.27	15.7	23	10	
18-Sep-02	53.3	6.13	16.0	24	13	
19-Sep-02	54.0	6.48	17.0	20	14	
20-Sep-02	54.0	6.23	16.3	12	5	
21-Sep-02	53.7	6.17	15.7	17	14	
22-Sep-02	53.0	5.88	15.7	16	14	
23-Sep-02	53.0	5.76	16.3	49	39	
24-Sep-02	53.0	5.56	15.7	12	14	
25-Sep-02	53.0	5.51	16.0	28	17	
26-Sep-02	54.0	5.78	15.7	17	5	
27-Sep-02	53.0	5.77	15.7	13	1	
28-Sep-02	53.0	5.71	16.0	10	4	
29-Sep-02	53.0	5.80	16.7	12	7	
30-Sep-02	53.7	6.09	14.7	30	10	
01-Oct-02	53.0	5.98	14.0	31	7	
02-Oct-02	54.7	6.63	13.7	11	7	Water release commenced.
03-Oct-02	64.7	12.70	14.7	534	264	
04-Oct-02	67.0	14.73	15.0	243	97	
05-Oct-02	66.0	14.07	16.0	62	11	
06-Oct-02	65.7	13.03	16.3	42	12	
07-Oct-02	64.0	11.95	16.0	115	21	
08-Oct-02	60.7	9.92	15.0	139	29	Water release terminated.
09-Oct-02	54.0	6.38	15.3	29	5	
10-Oct-02	53.3	6.12	13.7	28	6	
11-Oct-02	53.0	5.86	12.0	35	1	
12-Oct-02	53.0	5.83	11.7	11	3	
13-Oct-02	53.3	6.21	10.7	5	4	
14-Oct-02	53.0	6.02	11.7	12	1	
15-Oct-02	53.0	5.87	11.7	16	6	
16-Oct-02	52.7	5.79	12.3	10	5	
17-Oct-02	53.0	5.79	12.3	19	13	
18-Oct-02	53.0	5.76	12.3	6	9	
19-Oct-02	52.3	5.70	12.3	10	7	
20-Oct-02	52.7	5.63	13.0	19	12	
21-Oct-02	53.3	6.00	14.0	23	11	
22-Oct-02	53.0	5.94	13.7	41	28	
23-Oct-02	53.0	5.88	11.7	19	14	
24-Oct-02	53.0	6.18	10.7	28	5	
25-Oct-02	53.0	5.93	10.7	10	4	
26-Oct-02	52.3	5.68	11.3	7	18	
27-Oct-02	52.3	5.80	11.3	42	27	
28-Oct-02	53.3	5.93	11.0	21	19	

Table 17. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
29-Oct-02	52.7	5.75	10.3	31	21	
30-Oct-02	52.3	5.50	7.7	12	10	
31-Oct-02	52.3	5.56	7.3	6	4	
01-Nov-02	52.0	5.61	7.7	14	21	
02-Nov-02	51.7	5.41	8.0	20	15	
03-Nov-02	50.3	5.26	7.3	29	27	
04-Nov-02	50.0	5.08	6.7	26	40	
05-Nov-02	49.7	4.98	9.3	60	113	
06-Nov-02	51.3	5.32	10.0	127	193	
07-Nov-02	53.0	5.98	10.3	90	106	
08-Nov-02	54.3	6.49	10.3	61	60	
09-Nov-02	56.0	7.49	10.0	78	48	
10-Nov-02	55.3	7.15	10.0	44	32	
11-Nov-02	62.0	11.14	10.0	27	17	
12-Nov-02	76.0	20.37	10.0	71	23	
13-Nov-02	77.0	23.77	10.0	1	1	
				2,745	1,667	

Table 18. Daily counts and environmental information, Cowichan River enumeration fence, 2003.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
08-Sep-03	45.0	2.97	17.0	3	6	
09-Sep-03	45.0	2.86	17.0	3	2	
10-Sep-03	44.3	2.93	16.3	0	1	
11-Sep-03	45.0	3.14	17.7	3	5	
12-Sep-03	44.7	2.99	17.0	5	6	
13-Sep-03	44.0	3.05	17.0	5	4	
14-Sep-03	43.7	3.15	18.0	2	7	
15-Sep-03	43.0	2.82	17.0	4	20	
16-Sep-03	43.7	3.05	16.3	2	8	
17-Sep-03	43.0	3.10	16.0	2	3	
18-Sep-03	45.3	3.34	16.0	3	21	
19-Sep-03	44.0	3.37	16.0	4	9	
20-Sep-03	44.0	3.04	17.3	3	8	
21-Sep-03	43.0	3.01	17.0	8	16	

Table 18. Daily counts and environmental information, Cowichan River enumeration fence, 2003.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
22-Sep-03	43.3	3.03	18.0	1	9	
23-Sep-03	43.3	3.00	17.7	10	6	
24-Sep-03	43.0	2.94	16.7	2	2	
25-Sep-03	43.7	3.11	9.7	1	4	
26-Sep-03	43.3	2.98	11.7	4	6	
27-Sep-03	43.0	2.96	16.3	10	10	
28-Sep-03	43.0	N/A	16.7	5	10	
29-Sep-03	43.0	N/A	16.7	7	9	
30-Sep-03	43.0	N/A	15.7	4	3	
01-Oct-03	43.0	N/A	15.3	9	0	
02-Oct-03	43.0	N/A	17.0	16	18	
03-Oct-03	43.0	N/A	15.7	3	3	
04-Oct-03	43.0	N/A	16.0	2	3	
05-Oct-03	43.0	N/A	15.7	2	1	
06-Oct-03	53.7	N/A	15.0	136	135	24 hour water release.
07-Oct-03	52.7	5.59	16.3	523	501	
08-Oct-03	44.3	3.67	15.3	13	2	
09-Oct-03	45.7	4.53	15.0	31	26	
10-Oct-03	45.3	3.78	15.0	6	3	
11-Oct-03	45.0	3.90	14.7	5	8	
12-Oct-03	75.3	13.60	13.0	194	165	24 hour water release.
13-Oct-03	56.7	8.76	13.0	127	105	
14-Oct-03	47.3	4.50	12.0	3	2	
15-Oct-03	54.0	6.91	11.3	25	11	Water release commenced.
16-Oct-03	92.0	52.20	11.0	164	92	
				1,350	1,250	

Table 19. Daily counts and environmental information, Cowichan River enumeration fence, 2004.

Date	Mean Depth (cm)	Mean Discharge* (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
10-Sep-04	46.0	3.86	15.0	2	1	
11-Sep-04	47.3	6.13	16.3	7	0	
12-Sep-04	46.3	4.55	17.0	4	1	
13-Sep-04	45.0	4.38	15.3	2	5	
14-Sep-04	43.3	4.40	16.3	2	4	
15-Sep-04	49.0	5.92	15.3	1	9	
16-Sep-04	54.0	8.24	13.7	18	15	Flow incr. from 4.25 m^3/s to 7.08 m^3/s
17-Sep-04	55.7	9.99	14.0	113	47	
18-Sep-04	56.7	10.1	14.0	170	63	
19-Sep-04	55.3	9.65	12.3	12	4	
20-Sep-04	53.7	8.63	13.3	16	9	
21-Sep-04	52.3	7.67	14.7	34	21	
22-Sep-04	52.0	7.73	15.0	5	2	
23-Sep-04	52.0	7.66	14.3	5	6	
24-Sep-04	55.3	8.38	13.3	53	46	Flow incr. from 7.08 m^3/s to 14.16 m^3/s
25-Sep-04	64.7	14.9	14.0	405	239	
26-Sep-04	65.0	14.8	14.0	47	24	
27-Sep-04	65.0	14.7	15.7	53	27	
28-Sep-04	63.3	13.6	15.7	16	17	
29-Sep-04	64.7	14.3	15.3	16	15	Flow incr. from 14.16 m^3/s to 15.57 m^3/s
30-Sep-04	65.0	14.4	14.3	30	20	
01-Oct-04	65.0	14.9	15.0	26	8	
02-Oct-04	65.0	15.6	15.3	24	18	Flow incr. from 15.57 m^3/s to 16.99 m^3/s
03-Oct-04	65.7	15.7	14.7	18	5	
04-Oct-04	67.0	15.9	15.7	10	6	
05-Oct-04	66.7	16.2	15.7	47	11	
06-Oct-04	66.0	16.9	16.0	136	76	
07-Oct-04	67.3	16.7	15.0	11	4	
08-Oct-04	72.3	19.8	14.3	53	30	Flow incr. from 16.99 m^3/s to 22.65 m^3/s
09-Oct-04	79.0	27.1	14.0	131	49	Flow decr. from 22.65 m^3/s to 19.82 m^3/s
10-Oct-04	73.0	23.3	15.0	57	24	Flow decr. from 19.82 m^3/s to 16.99 m^3/s
11-Oct-04	70.0	19.3	15.3	3	3	
12-Oct-04	69.0	19.7	16.0	17	11	
13-Oct-04	70.0	20.8	14.3	25	5	
14-Oct-04	74.7	23.1	15.7	26	4	Flow incr. from 16.99 m^3/s to 22.65 m^3/s
15-Oct-04	77.0	22.8	15.3	23	7	
16-Oct-04	75.7	22.7	15.0	7	3	
17-Oct-04	78.0	22.9	15.3	32	5	
18-Oct-04	80.0	25.5	14.0	118	34	
19-Oct-04	83.3	28.4	13.0	36	35	
20-Oct-04	85.0	30.1	13.7	47	22	
21-Oct-04	80.3	27.2	13.7	10	7	

Table 19. (continued)

Date	Mean Depth (cm)	Mean Discharge* (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
22-Oct-04	78.7	26.5	15.7	5	3	
23-Oct-04	78.3	25.0	13.3	4	3	
24-Oct-04	77.7	24.1	13.3	3	2	
25-Oct-04	79.3	26.1	13.3	20	11	
26-Oct-04	84.0	32.2	12.0	56	14	
27-Oct-04	82.5	31.4	12.0	46	28	
				2,002	1,003	

* Mean discharge is preliminary and subject to revision.

Table 20. Daily counts and environmental information, Nanaimo River enumeration fence, 1995.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
08-Aug-95	66	5.87	18	2	1	
09-Aug-95	70	5.12	19	0	0	
10-Aug-95	82	4.74	19	1	0	
11-Aug-95	86	4.52	19	0	0	
12-Aug-95	85	4.25	19	0	0	
13-Aug-95	79	4.03	19	0	1	
14-Aug-95	85	3.95	19	0	1	
15-Aug-95	82	4.05	18	0	1	
16-Aug-95	76	4.67	18	0	0	
17-Aug-95	71	4.82	18	0	0	
18-Aug-95	54	4.62	18	0	0	
19-Aug-95	60	4.69	18	0	1	
20-Aug-95	61	5.18	18	1	2	
21-Aug-95	61	5.09	18	1	2	
22-Aug-95	62	4.95	19	0	0	
23-Aug-95	62	4.61	18	0	0	
24-Aug-95	61	4.36	18	4	5	
25-Aug-95	63	4.17	18	2	4	
26-Aug-95	77	4.68	18	2	6	
27-Aug-95	71	4.19	18	1	2	
28-Aug-95	68	3.93	19	0	2	
29-Aug-95	72	4.33	19	3	10	
30-Aug-95	79	4.42	18	2	3	
31-Aug-95	82	4.39	18	0	5	
01-Sep-95	100	4.20	18	0	0	
02-Sep-95	77	4.18	19	0	1	
03-Sep-95	74	3.80	19	0	1	
04-Sep-95	64	4.07	18	3	0	
05-Sep-95	58	4.33	18	0	2	
06-Sep-95	61	4.24	18	0	1	
07-Sep-95	64	4.28	19	0	2	
08-Sep-95	61	4.12	19	555	819	Chinook transported upstream.
09-Sep-95	76	3.65	20	1	10	
10-Sep-95	67	3.73	20	2	2	
11-Sep-95	57	3.67	20	3	4	
12-Sep-95	62	4.12	19	18	20	
13-Sep-95	68	3.61	19	14	50	
14-Sep-95	71	4.31	19	8	64	
15-Sep-95	70	4.27	19	3	12	
16-Sep-95	65	4.44	19	0	1	

Table 20. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
17-Sep-95	63	4.39	18	3	2	
18-Sep-95	60	4.50	19	1	0	
19-Sep-95	60	4.48	19	0	1	
20-Sep-95	58	4.53	18	3	3	
21-Sep-95	61	4.47	18	0	1	
22-Sep-95	59	4.44	18	0	2	
23-Sep-95	63	4.43	19	3	3	
24-Sep-95	75	5.07	17	11	38	Water released from Fourth Lake.
25-Sep-95	85	8.22	17	8	46	Water released from Jump Lake.
26-Sep-95	76	10.80	17	1,122	1,889	
27-Sep-95	72	9.20	17	29	22	
28-Sep-95	77	6.59	16	4	6	Water release terminated.
29-Sep-95	76	5.67	16	1	4	
30-Sep-95	77	5.07	16	0	0	
01-Oct-95	78	4.80	16	0	0	
02-Oct-95	80	4.93	14	9	48	
03-Oct-95	113	5.65	15	57	85	
04-Oct-95	74	5.52	14	0	1	
05-Oct-95	60	5.37	14	0	0	
06-Oct-95	64	5.28	12	1	5	
07-Oct-95	70	5.31	14	0	12	
08-Oct-95	83	5.93	14	4	59	
09-Oct-95	74	6.97	14	11	31	
10-Oct-95	107	29.20	13	5	15	
11-Oct-95	112	37.90	12	1	10	
12-Oct-95	105	32.70	13	3	6	
13-Oct-95	95	24.20	12	1	0	
14-Oct-95	103	29.70	12	0	0	
15-Oct-95	108	32.90	11	0	0	
16-Oct-95	108	38.30	12	0	0	
				1,903	3,324	

Table 21. Daily counts and environmental information, Nanaimo River enumeration fence, 1996.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
14-Aug-96	N/A	4.80	N/A	1	0	
15-Aug-96	59.7	4.68	21.0	2	84	
16-Aug-96	64.3	4.46	20.0	0	0	
17-Aug-96	64.7	4.32	20.0	0	1	
18-Aug-96	61.3	4.32	19.3	0	0	
19-Aug-96	61.0	4.28	18.3	0	1	
20-Aug-96	61.3	4.33	18.3	0	0	
21-Aug-96	62.0	4.25	18.3	0	0	
22-Aug-96	63.7	4.29	17.7	0	0	
23-Aug-96	73.7	4.28	19.0	0	0	
24-Aug-96	83.0	4.35	20.0	0	2	
25-Aug-96	77.0	4.24	20.3	0	1	
26-Aug-96	66.7	4.23	20.0	0	1	
27-Aug-96	60.0	4.29	20.0	0	0	
28-Aug-96	58.0	4.19	20.3	0	0	
29-Aug-96	60.0	4.71	20.3	0	1	
30-Aug-96	72.7	4.87	20.3	0	2	
31-Aug-96	61.3	4.46	20.0	0	2	
01-Sep-96	61.0	4.34	19.7	0	0	
02-Sep-96	61.0	4.33	19.0	0	0	
03-Sep-96	61.0	4.50	18.7	1	1	
04-Sep-96	60.0	4.74	17.7	0	3	
05-Sep-96	66.7	4.69	17.7	1	2	
06-Sep-96	64.0	4.65	16.3	0	1	
07-Sep-96	71.0	4.53	18.0	213	58	
08-Sep-96	65.3	4.58	17.0	24	7	
09-Sep-96	61.0	4.53	17.0	4	7	
10-Sep-96	60.0	4.37	17.0	1	1	
11-Sep-96	67.7	4.24	17.7	15	9	
12-Sep-96	67.7	4.19	17.7	179	130	
13-Sep-96	80.7	4.13	17.3	5	0	
14-Sep-96	63.0	4.21	18.0	26	24	
15-Sep-96	66.7	4.65	16.0	1	0	
16-Sep-96	64.0	5.04	16.3	7	8	
17-Sep-96	61.3	5.21	16.7	498	489	Chinook transported upstream.
18-Sep-96	72.0	5.11	15.3	26	5	
19-Sep-96	69.0	5.06	15.0	13	27	
20-Sep-96	62.3	4.82	15.0	1	1	
21-Sep-96	62.3	4.54	14.0	0	0	
22-Sep-96	66.3	4.27	14.0	0	1	
23-Sep-96	58.0	4.12	12.7	9	14	
24-Sep-96	59.7	4.64	13.3	9	8	

Table 21. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
25-Sep-96	65.0	7.08	13.0	28	7	
26-Sep-96	80.3	8.56	12.7	6	9	Water release commences.
27-Sep-96	84.3	5.86	13.3	1	4	
28-Sep-96	62.3	5.21	13.0	0	2	
29-Sep-96	64.0	4.78	14.3	0	0	Water release terminated.
30-Sep-96	67.3	4.46	13.0	0	1	
01-Oct-96	65.3	4.21	12.7	0	0	
02-Oct-96	66.0	4.13	12.3	2	0	
03-Oct-96	61.0	4.19	12.0	2	2	
04-Oct-96	65.0	8.26	12.7	0	0	
05-Oct-96	78.3	13.50	12.0	2	1	
06-Oct-96	74.0	13.70	13.0	0	0	
07-Oct-96	76.3	11.70	13.7	1	4	
08-Oct-96	73.3	9.63	14.0	4	2	
09-Oct-96	72.3	9.23	14.3	6	3	
10-Oct-96	71.3	11.70	14.0	19	8	
11-Oct-96	87.7	14.40	13.3	42	9	Water release commences.
12-Oct-96	82.3	11.60	12.3	0	0	
13-Oct-96	85.0	14.20	11.0	88	20	
14-Oct-96	104.3	23.20	11.7	2	0	Water release terminated.
				1,239	9,63	

Table 22. Daily counts and environmental information, Nanaimo River enumeration fence, 1997.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
08-Sep-97	55.0	5.53	17.0	25	0	
09-Sep-97	68.3	5.25	17.7	0	0	
10-Sep-97	61.7	4.99	17.7	8	5	
11-Sep-97	80.7	4.82	19.7	3	2	Water release commenced.
12-Sep-97	84.0	5.45	17.7	2	0	
13-Sep-97	52.7	5.98	18.0	31	7	
14-Sep-97	54.7	7.43	17.3	10	53	Water release terminated.
15-Sep-97	73.0	11.90	17.0	30	5	
16-Sep-97	73.7	13.40	16.0	5	4	
17-Sep-97	103.3	30.60	15.0	465	49	
18-Sep-97	127.0	41.40	15.0	13	4	
19-Sep-97	112.0	38.90	N/A	15	7	
20-Sep-97	106.0	30.90	N/A	8	9	
21-Sep-97	95.3	23.30	N/A	0	1	
22-Sep-97	87.3	19.00	16.0	1	1	
23-Sep-97	83.0	16.20	16.3	12	14	
24-Sep-97	89.0	14.70	17.0	16	13	
25-Sep-97	92.3	14.30	16.7	26	8	
26-Sep-97	72.0	18.50	17.5	8	1	
27-Sep-97	123.0	55.20	N/A	3	4	
28-Sep-97	142.0	82.80	N/A	1	2	
29-Sep-97	149.3	78.50	14.0	1	0	
30-Sep-97	134.0	64.20	15.0	1	0	
01-Oct-97	144.0	101.00	14.0	0	0	
				684	189	

Table 23. Daily counts and environmental information, Nanaimo River enumeration fence, 1998.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
04-Sep-98	17.0	4.00	21.3	1	3	
05-Sep-98	15.7	4.05	20.3	0	1	
06-Sep-98	20.0	4.09	18.3	0	1	
07-Sep-98	23.0	4.17	20.0	0	0	
08-Sep-98	28.0	4.33	18.3	0	0	
09-Sep-98	25.7	4.23	17.7	0	0	
10-Sep-98	20.3	4.19	18.3	0	0	
11-Sep-98	22.7	4.21	19.7	0	0	
12-Sep-98	20.7	4.14	18.7	0	1	
13-Sep-98	25.3	4.11	20.0	0	3	
14-Sep-98	23.7	4.07	19.0	3	8	
15-Sep-98	25.7	4.00	18.3	4	7	
16-Sep-98	31.0	3.93	18.7	1	0	
17-Sep-98	22.7	4.00	17.3	0	2	
18-Sep-98	24.0	4.20	18.3	0	3	
19-Sep-98	23.3	4.28	17.7	5	19	
20-Sep-98	23.3	4.19	18.7	1	4	
21-Sep-98	35.3	4.14	17.0	10	1	
22-Sep-98	25.3	4.08	16.7	0	0	
23-Sep-98	25.3	3.92	18.0	13	8	
24-Sep-98	24.0	3.87	16.3	0	1	Water release commenced.
25-Sep-98	28.0	4.71	17.3	0	0	
26-Sep-98	36.0	7.67	18.0	36	25	
27-Sep-98	41.3	10.90	16.7	418	101	
28-Sep-98	47.3	12.80	18.0	26	26	Water release terminated.
29-Sep-98	46.3	11.80	17.0	27	3	
30-Sep-98	38.3	8.69	17.0	5	9	
01-Oct-98	37.7	7.04	16.7	2	11	
02-Oct-98	36.3	6.21	15.3	38	33	
03-Oct-98	27.3	5.93	13.3	5	19	
04-Oct-98	32.3	6.58	14.0	10	27	
05-Oct-98	30.7	5.66	15.0	3	5	
06-Oct-98	29.0	5.37	16.0	7	5	
07-Oct-98	36.0	4.97	16.0	9	8	
08-Oct-98	37.7	4.68	16.0	7	12	
09-Oct-98	27.7	6.33	14.7	122	88	
10-Oct-98	22.0	6.90	15.3	52	12	
11-Oct-98	25.3	6.89	14.7	43	15	
12-Oct-98	30.3	13.60	14.7	43	23	
13-Oct-98	78.7	30.90	14.0	69	56	
14-Oct-98	84.7	32.50	11.7	13	18	

Table 23. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
15-Oct-98	76.3	25.50	12.7	50	9	
16-Oct-98	55.0	18.80	12.0	1	2	
17-Oct-98	43.7	16.60	12.3	14	19	
18-Oct-98	53.0	19.60	11.7	10	15	
19-Oct-98	56.0	18.10	10.0	0	9	
				1,048	612	

Table 24. Daily counts and environmental information, Nanaimo River enumeration fence, 1999.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
21-Sep-99	46.0	5.20	N/A	0	0	
22-Sep-99	40.0	5.29	18.0	0	0	
23-Sep-99	31.7	5.36	17.3	1	5	
24-Sep-99	42.0	5.38	18.0	1	16	
25-Sep-99	44.3	6.00	14.7	2	2	
26-Sep-99	45.0	6.27	13.3	4	1	
27-Sep-99	36.3	6.19	13.3	0	2	
28-Sep-99	45.0	5.98	13.0	1	1	
29-Sep-99	44.5	5.81	14.0	2	0	
30-Sep-99	41.0	5.56	14.0	1	2	
01-Oct-99	42.7	5.31	13.0	3	4	Water release commenced.
02-Oct-99	49.7	5.78	12.7	6	2	
03-Oct-99	48.7	8.78	12.0	50	16	
04-Oct-99	56.0	11.90	12.0	32	9	Water release terminated.
				103	60	

Table 25. Daily counts and environmental information, Nanaimo River enumeration fence, 2000.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
06-Sep-00	N/A	4.27	N/A	0	0	
07-Sep-00	21.0	4.25	15.0	0	0	
08-Sep-00	20.5	4.63	15.0	1	0	
09-Sep-00	25.7	4.85	15.0	3	0	
10-Sep-00	25.5	5.31	14.0	3	0	
11-Sep-00	27.0	5.92	14.0	0	0	
12-Sep-00	26.3	6.29	15.3	0	1	
13-Sep-00	25.0	5.95	15.3	2	4	
14-Sep-00	23.3	5.44	16.0	3	4	
15-Sep-00	26.0	4.91	16.7	19	14	
16-Sep-00	22.0	4.64	17.3	6	5	
17-Sep-00	20.5	4.47	17.3	1	5	
18-Sep-00	15.3	4.29	17.3	0	2	
19-Sep-00	15.0	4.27	17.7	0	2	
20-Sep-00	14.7	4.31	16.3	6	11	
21-Sep-00	15.3	4.39	17.0	11	10	
22-Sep-00	16.0	4.35	15.0	2	15	
23-Sep-00	17.7	4.39	13.7	8	11	
24-Sep-00	18.3	4.39	12.7	0	7	
25-Sep-00	18.3	4.38	13.0	0	9	Water release commenced.
26-Sep-00	17.0	4.89	13.3	9	14	
27-Sep-00	21.7	7.89	12.0	48	100	
28-Sep-00	39.3	10.80	15.3	386	347	
29-Sep-00	37.3	12.00	14.7	18	28	
30-Sep-00	45.0	11.80	14.0	16	18	
01-Oct-00	35.0	9.92	15.0	1	1	
02-Oct-00	33.0	8.35	12.7	6	7	Water release terminated.
03-Oct-00	28.7	7.14	13.0	14	25	
04-Oct-00	27.3	6.36	11.7	3	5	
05-Oct-00	24.7	5.91	11.7	2	6	
06-Oct-00	24.7	5.60	11.3	1	2	
07-Oct-00	23.3	5.37	10.0	1	0	
08-Oct-00	27.3	5.24	10.3	0	3	
09-Oct-00	25.7	5.33	11.3	8	0	
10-Oct-00	21.7	5.29	12.0	19	14	
11-Oct-00	21.3	4.93	12.0	89	9	
12-Oct-00	19.3	4.81	10.7	58	25	
13-Oct-00	18.0	4.77	10.0	39	4	
14-Oct-00	29.7	4.75	11.0	29	5	
15-Oct-00	28.0	4.70	10.3	51	1	
16-Oct-00	26.3	5.83	10.3	9	0	
17-Oct-00	54.0	26.70	10.0	14	1	
				886	715	

Table 26. Daily counts and environmental information, Nanaimo River enumeration fence, 2001.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
10-Sep-01	N/A	5.69	N/A	0	0	
11-Sep-01	N/A	5.40	N/A	0	2	
12-Sep-01	19.0	4.26	19.0	0	6	
13-Sep-01	24.7	5.08	16.7	3	11	
14-Sep-01	24.3	4.10	16.7	6	13	
15-Sep-01	36.0	4.83	18.0	7	10	
16-Sep-01	23.0	5.45	16.0	9	6	
17-Sep-01	21.0	5.48	15.3	6	40	
18-Sep-01	27.3	5.56	16.0	7	21	
19-Sep-01	27.3	5.49	15.0	15	23	
20-Sep-01	27.3	5.44	15.0	3	16	
21-Sep-01	23.0	5.44	16.0	2	3	
22-Sep-01	18.0	5.43	16.0	24	28	
23-Sep-01	20.3	5.42	15.3	1	9	
24-Sep-01	20.7	5.37	15.7	11	36	Water release commenced.
25-Sep-01	27.3	6.72	14.0	29	38	
26-Sep-01	39.0	11.60	16.0	124	27	
27-Sep-01	44.0	15.50	15.0	124	111	Water release terminated.
28-Sep-01	47.3	15.20	14.0	62	65	
29-Sep-01	39.7	12.40	14.0	37	29	
30-Sep-01	36.7	11.50	14.0	22	28	
01-Oct-01	37.0	10.10	14.7	12	22	
02-Oct-01	34.3	8.79	13.0	24	8	
03-Oct-01	31.0	7.12	13.0	40	28	
04-Oct-01	27.0	6.40	13.0	11	23	
05-Oct-01	23.0	5.90	11.7	12	11	
06-Oct-01	18.0	5.55	11.5	4	6	
07-Oct-01	18.3	5.25	12.0	13	9	
08-Oct-01	18.0	5.13	11.7	21	8	
09-Oct-01	20.0	5.01	11.3	49	4	
10-Oct-01	27.3	5.27	10.7	79	16	
11-Oct-01	28.0	6.18	10.7	79	22	
12-Oct-01	40.3	6.87	11.0	33	10	
13-Oct-01	45.0	9.54	10.0	13	6	
14-Oct-01	50.0	10.90	11.0	19	14	
15-Oct-01	39.3	11.30	10.3	269	9	
16-Oct-01	38.7	10.50	10.3	341	14	
17-Oct-01	38.0	9.65	10.0	84	5	
18-Oct-01	43.3	8.77	10.0	86	6	
19-Oct-01	42.7	7.96	10.7	24	12	
20-Oct-01	39.3	7.47	10.0	11	10	
21-Oct-01	30.7	7.26	10.0	19	7	

Table 26. (continued).

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
22-Oct-01	33.0	8.39	9.7	12	12	
23-Oct-01	66.7	24.00	9.3	88	19	
24-Oct-01	78.3	28.80	9.3	12	5	
25-Oct-01	68.3	24.70	9.7	0	1	
26-Oct-01	63.7	26.90	10.0	3	5	
27-Oct-01	94.7	41.10	9.7	5	14	
28-Oct-01	87.3	34.50	8.7	5	2	
29-Oct-01	72.7	25.50	8.0	62	20	
30-Oct-01	62.0	20.20	8.0	23	0	
				1,945	850	

Table 27. Daily counts and environmental information, Nanaimo River enumeration fence, 2002.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
04-Sep-02	N/A	4.77	N/A	0	0	
05-Sep-02	N/A	4.79	17.0	0	0	
06-Sep-02	N/A	4.68	17.5	0	0	
07-Sep-02	N/A	4.70	17.0	0	1	
08-Sep-02	33.0	4.69	15.7	0	3	
09-Sep-02	22.0	4.78	15.7	0	4	
10-Sep-02	31.7	5.10	17.0	1	2	
11-Sep-02	32.0	4.97	17.7	0	2	
12-Sep-02	30.7	4.79	18.0	0	0	
13-Sep-02	31.7	4.54	17.7	1	6	
14-Sep-02	28.3	4.38	18.7	2	1	
15-Sep-02	35.0	4.29	18.0	1	1	
16-Sep-02	33.3	4.29	17.7	3	3	
17-Sep-02	36.0	4.47	16.0	0	1	
18-Sep-02	28.3	4.49	15.7	1	3	
19-Sep-02	31.3	4.42	16.0	3	8	
20-Sep-02	30.0	4.47	15.7	0	6	
21-Sep-02	30.0	4.63	16.5	9	1	
22-Sep-02	29.0	4.63	16.0	20	4	

Table 27. (continued)

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
23-Sep-02	30.3	4.54	15.7	4	1	
24-Sep-02	28.7	4.39	16.7	2	9	
25-Sep-02	29.7	4.29	15.7	12	9	
26-Sep-02	29.3	4.14	15.3	3	2	
27-Sep-02	26.0	4.03	15.0	0	0	
28-Sep-02	26.0	3.92	15.3	1	9	
29-Sep-02	24.3	3.86	15.3	87	57	
30-Sep-02	25.0	3.86	11.5	3	5	Water release commenced.
01-Oct-02	28.0	4.28	14.3	1	3	
02-Oct-02	33.0	7.20	13.7	142	63	
03-Oct-02	43.3	10.90	13.0	490	201	Water release terminated.
04-Oct-02	43.0	9.93	13.3	131	31	
05-Oct-02	38.7	7.17	13.7	6	6	
06-Oct-02	34.0	5.77	13.3	7	3	
07-Oct-02	34.3	5.02	13.3	2	1	
08-Oct-02	35.7	4.60	14.0	2	3	
09-Oct-02	30.3	4.32	14.0	7	5	
10-Oct-02	27.3	4.01	12.0	12	3	
11-Oct-02	26.7	3.73	12.7	3	0	
12-Oct-02	25.3	3.73	11.0	7	5	
13-Oct-02	27.0	3.87	11.0	0	1	
14-Oct-02	28.0	3.86	8.7	5	6	
15-Oct-02	28.3	3.85	9.0	2	1	
16-Oct-02	24.7	3.83	10.0	0	0	
17-Oct-02	23.5	3.68	N/A	2	0	
18-Oct-02	28.7	3.66	10.0	1	0	
19-Oct-02	23.7	3.65	10.0	10	1	
20-Oct-02	24.7	3.74	10.0	2	4	
21-Oct-02	24.0	3.79	11.0	29	7	
22-Oct-02	25.7	3.82	10.3	14	10	
23-Oct-02	24.0	3.79	10.0	19	10	
24-Oct-02	27.7	3.77	9.7	28	12	
25-Oct-02	25.0	3.75	9.3	15	2	
26-Oct-02	23.7	3.73	9.7	3	0	
27-Oct-02	27.0	3.73	9.0	4	0	
28-Oct-02	22.0	3.72	8.0	2	0	
				1,099	516	

Table 28. Daily counts and environmental information, Nanaimo River enumeration fence, 2003.

Date	Mean Depth (cm)	Mean Discharge (m^3/s)	Mean Temp (° C)	Adult Chinook	Jack Chinook	Comments
12-Sep-03	N/A	4.21	N/A	4	4	
13-Sep-03	N/A	4.06	N/A	0	2	
14-Sep-03	N/A	4.06	N/A	3	1	
15-Sep-03	18.5	4.01	14.5	6	5	
16-Sep-03	18.0	3.96	14.0	4	1	
17-Sep-03	16.3	3.86	13.3	7	4	
18-Sep-03	16.3	3.88	12.0	3	6	
19-Sep-03	19.7	4.87	14.3	70	14	
20-Sep-03	24.7	4.95	14.3	7	6	
21-Sep-03	26.0	4.86	13.3	9	6	
22-Sep-03	25.0	4.69	15.0	1	0	
23-Sep-03	22.7	4.48	14.3	1	0	
24-Sep-03	22.0	4.33	13.0	4	4	
25-Sep-03	22.0	4.20	13.7	0	0	
26-Sep-03	19.3	4.08	14.0	23	6	
27-Sep-03	25.7	3.94	15.3	1	3	
28-Sep-03	24.0	3.84	14.3	25	4	
29-Sep-03	18.0	3.75	14.0	122	5	
30-Sep-03	16.0	3.70	15.3	59	10	
01-Oct-03	16.0	3.73	15.7	17	3	
02-Oct-03	16.0	3.81	15.7	2	3	
03-Oct-03	15.7	3.91	13.7	5	1	
04-Oct-03	20.3	3.84	14.7	6	2	
05-Oct-03	23.7	3.87	13.7	7	2	
06-Oct-03	30.7	4.10	12.3	35	3	Water release commenced.
07-Oct-03	33.3	5.38	13.3	215	50	
08-Oct-03	43.0	11.40	13.3	508	208	
09-Oct-03	70.0	25.70	11.7	278	152	
10-Oct-03	76.7	27.50	11.7	34	35	Water release terminated.
11-Oct-03	72.0	22.90	13.0	9	2	
12-Oct-03	70.0	71.80	12.0	2	1	
				1,467	543	

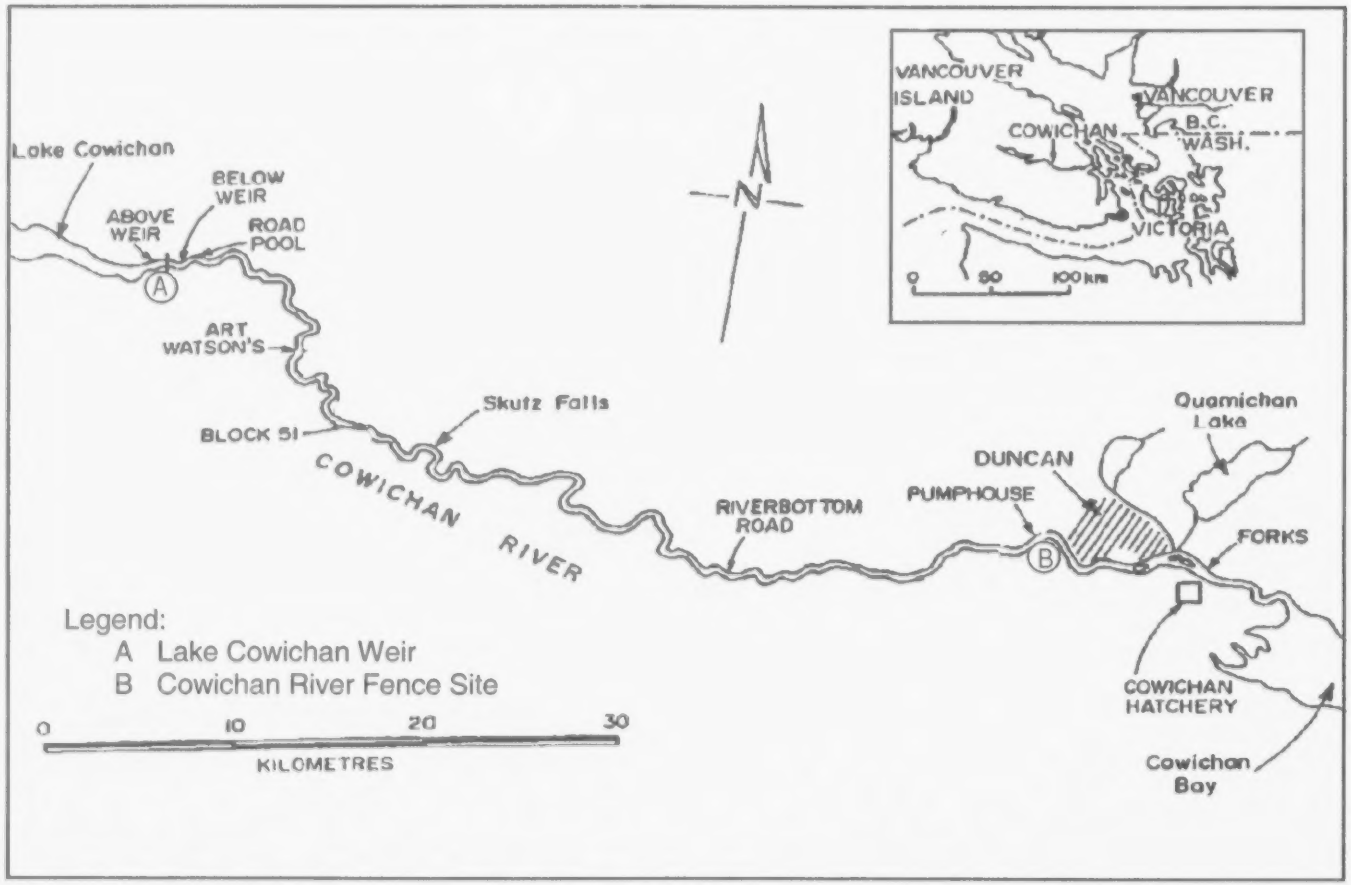
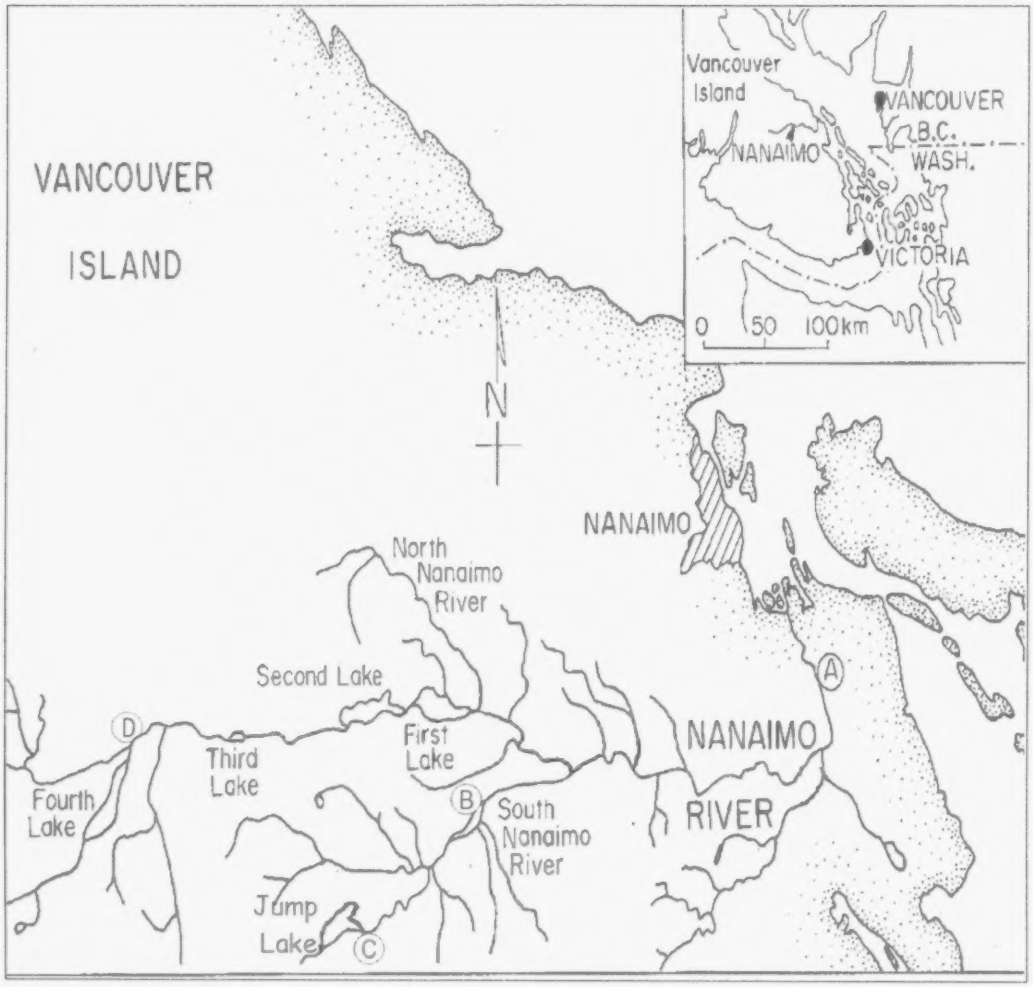


Figure 1. Cowichan River Watershed study area.



Legend:

- A Nanaimo River Fence Site
- B South Nanaimo River Dam
- C Jump Lake Dam
- D Fourth Lake Dam

Figure 2. Nanaimo River Watershed study area.

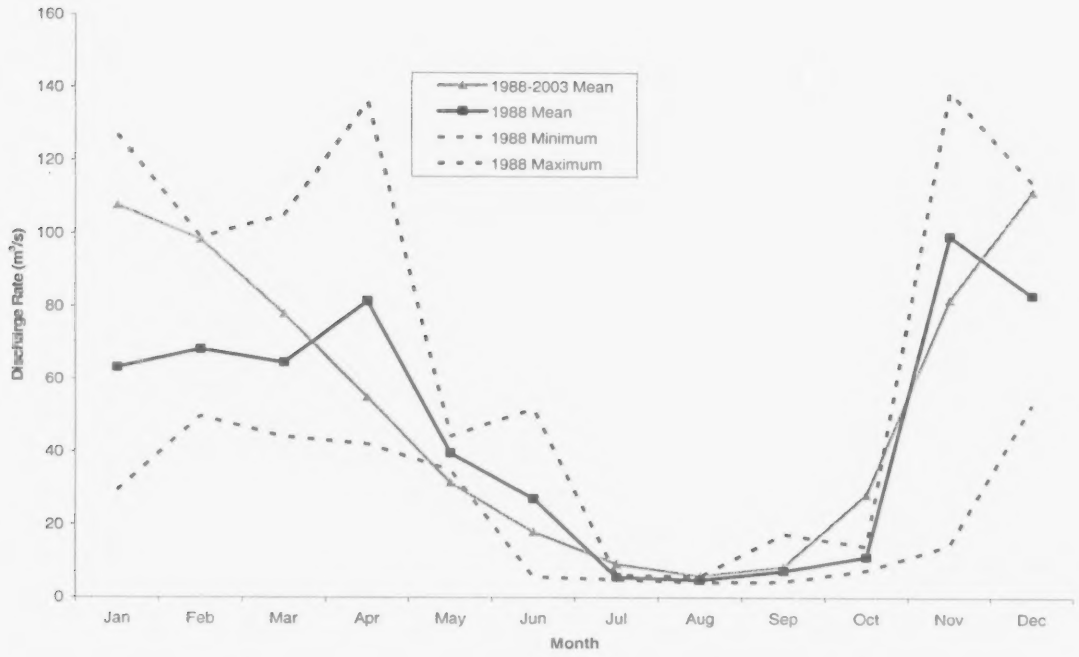


Figure 3. Monthly Cowichan River discharge (m^3/s) in 1988 along with period mean.

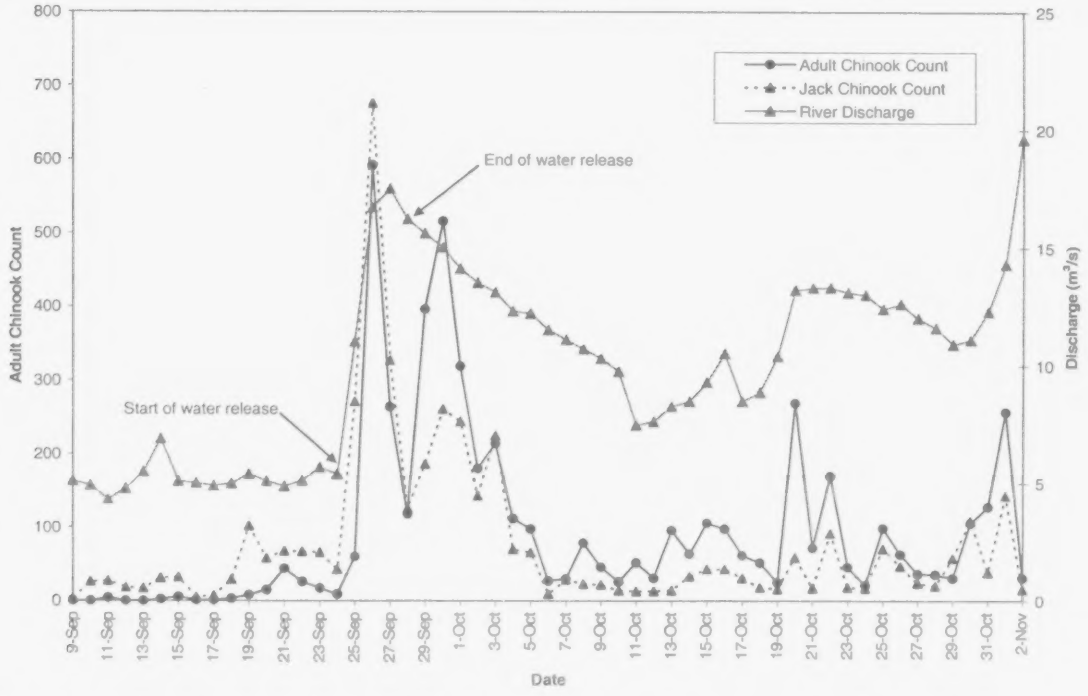


Figure 4. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1988.

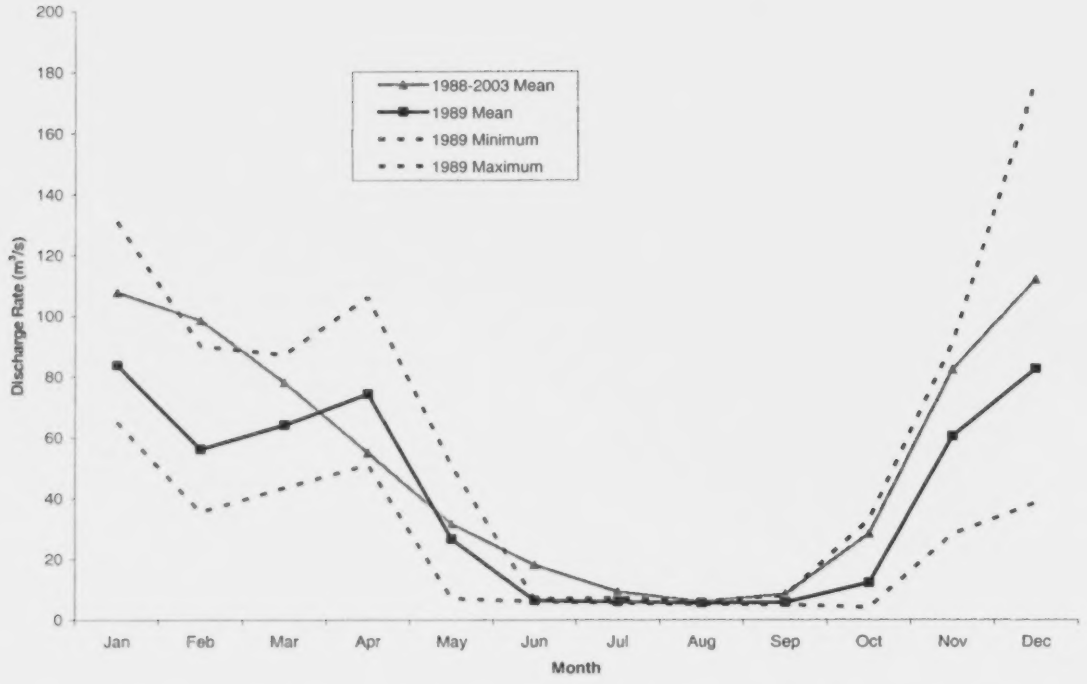


Figure 5. Monthly Cowichan River discharge (m^3/s) in 1989 along with period mean.

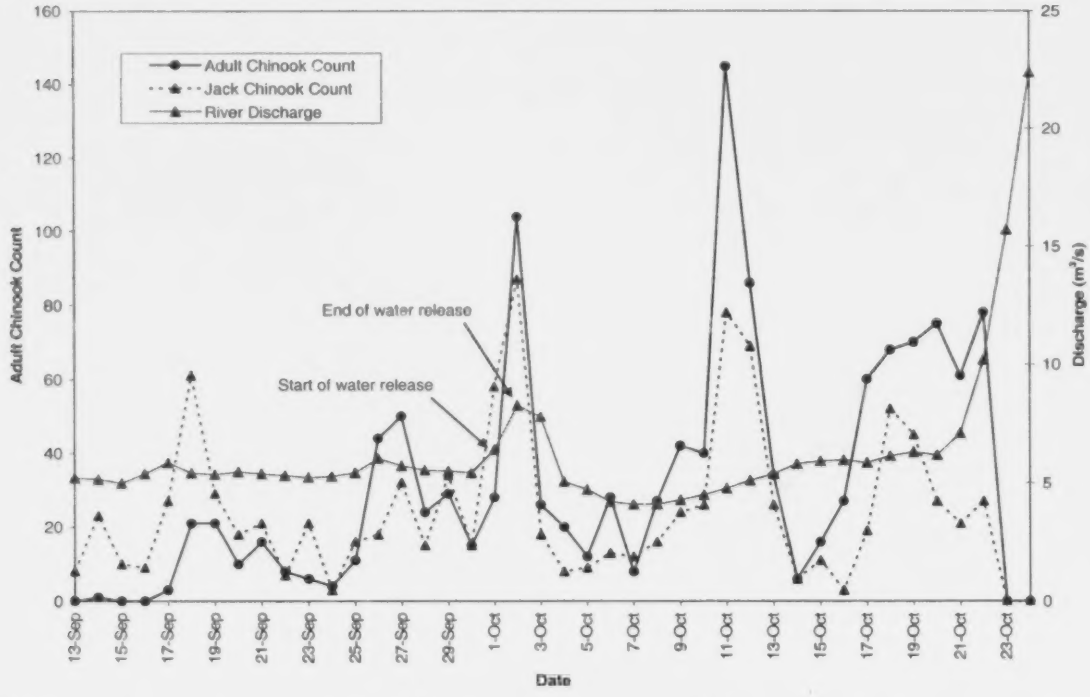


Figure 6. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1989.

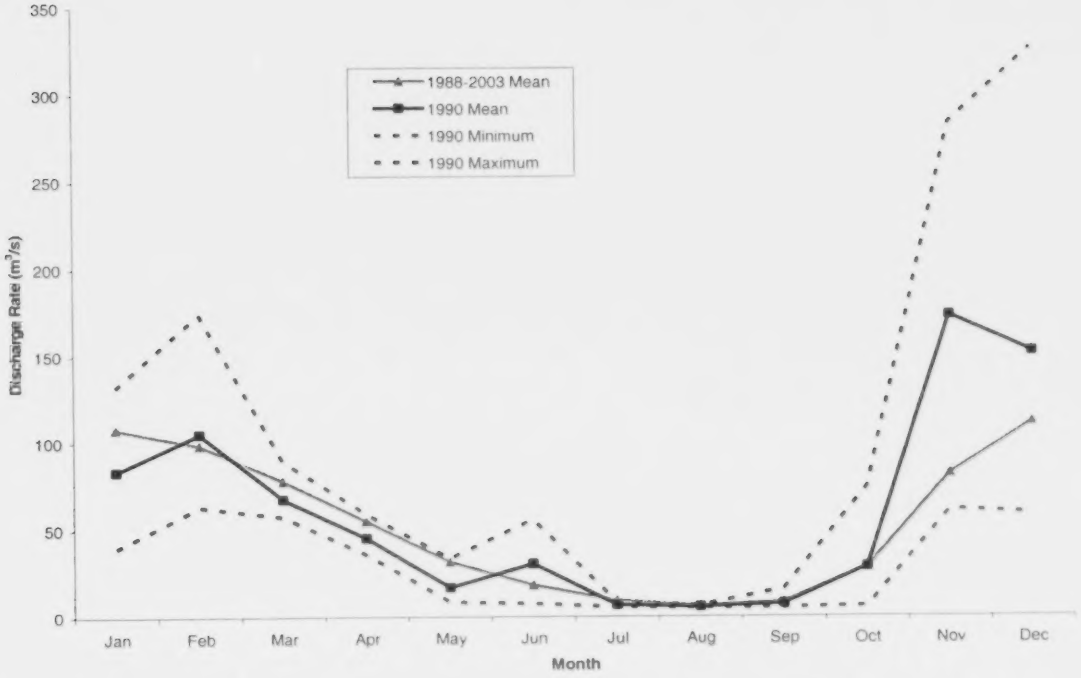


Figure 7. Monthly Cowichan River discharge (m^3/s) in 1990 along with period mean.

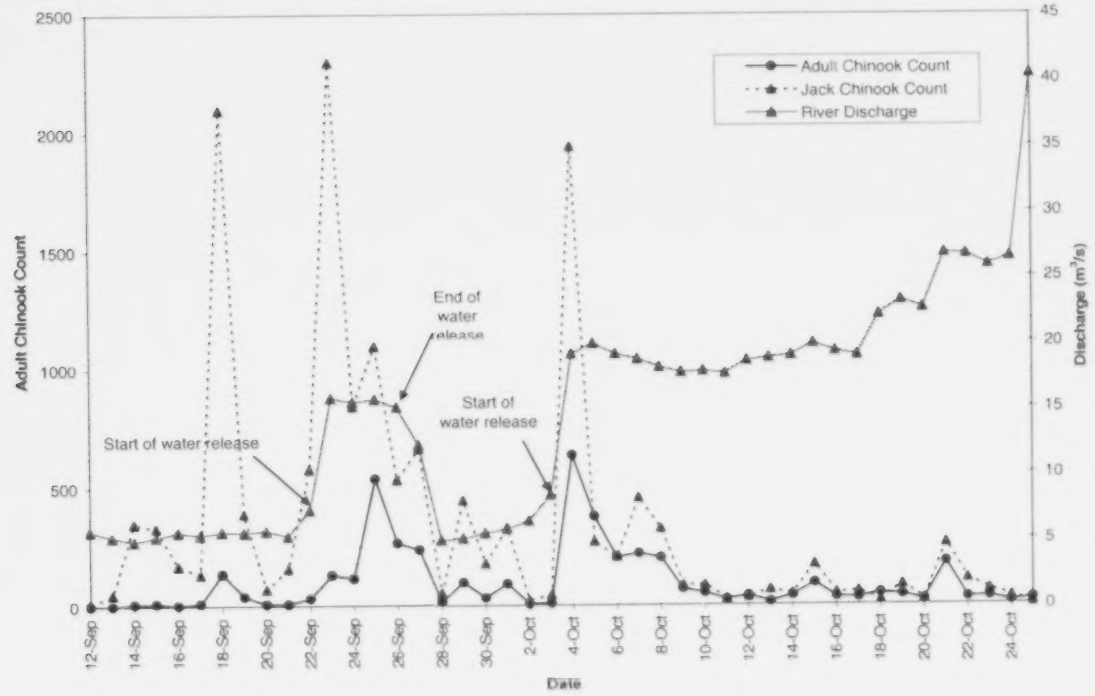


Figure 8. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1990.

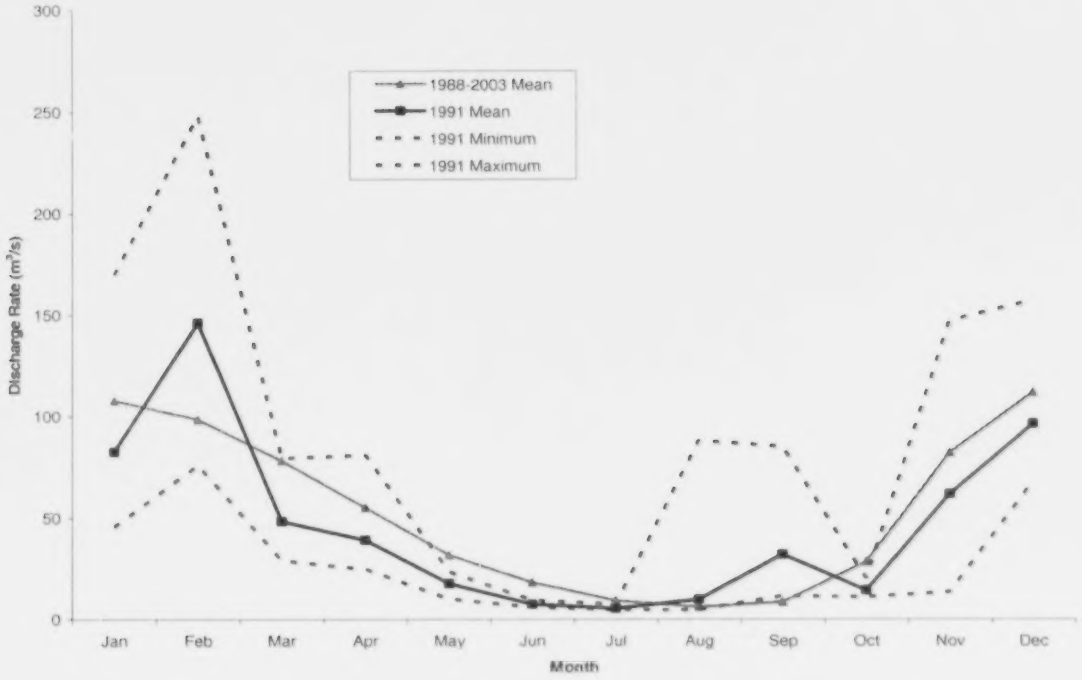


Figure 9. Monthly Cowichan River discharge (m^3/s) in 1991 along with period mean.

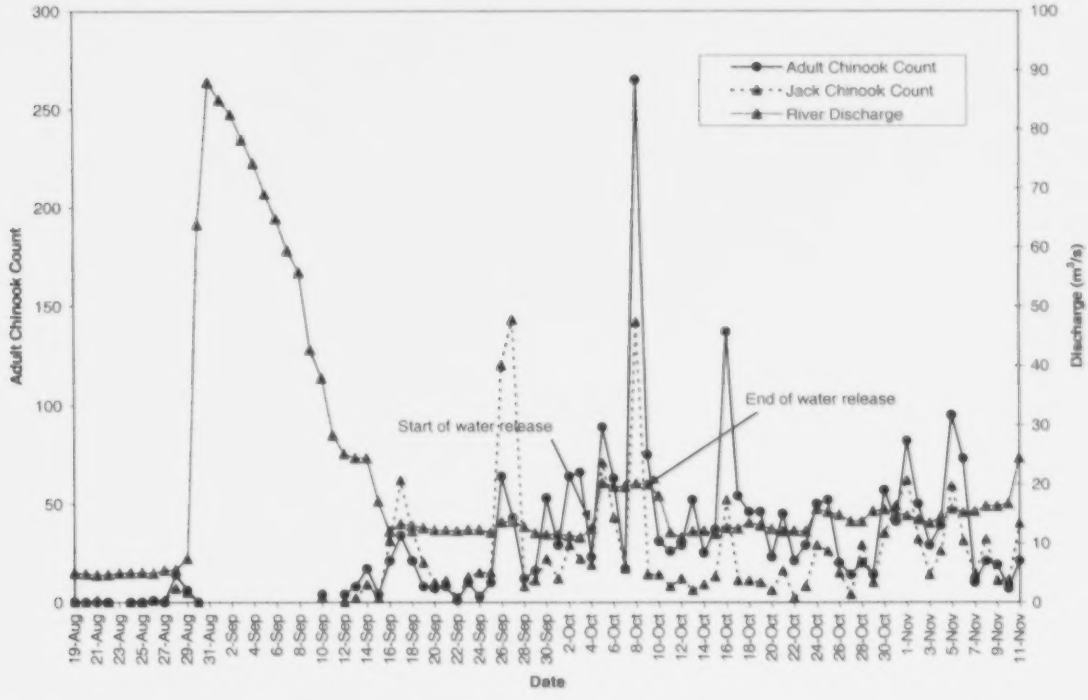


Figure 10. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1991.

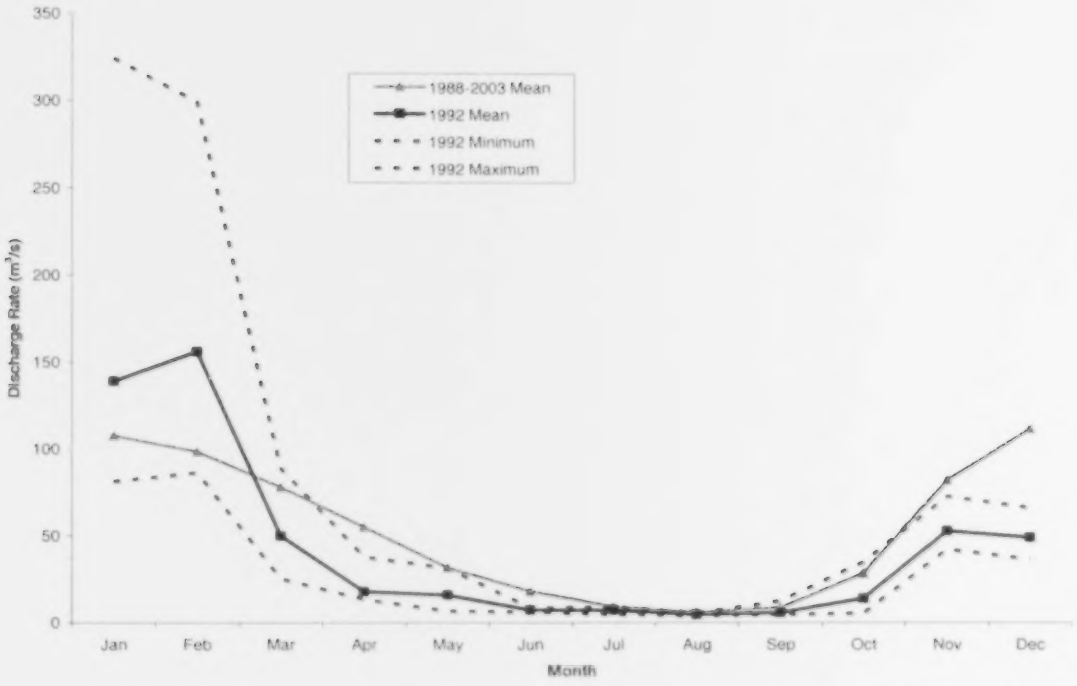


Figure 11. Monthly Cowichan River discharge (m^3/s) in 1992 along with period mean.

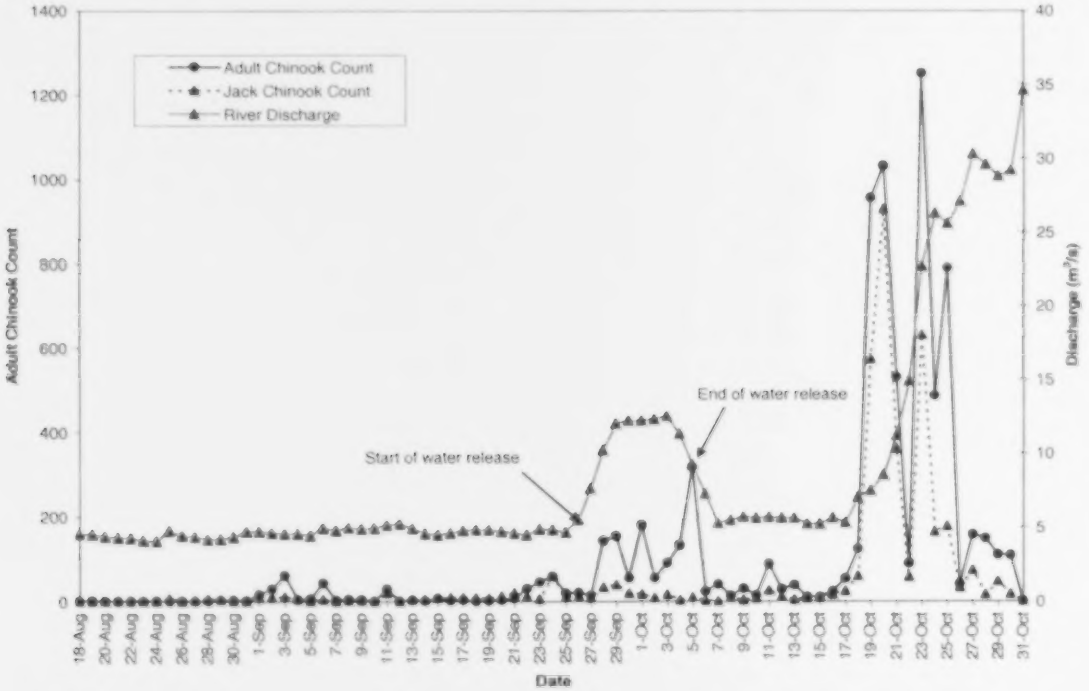


Figure 12. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1992.

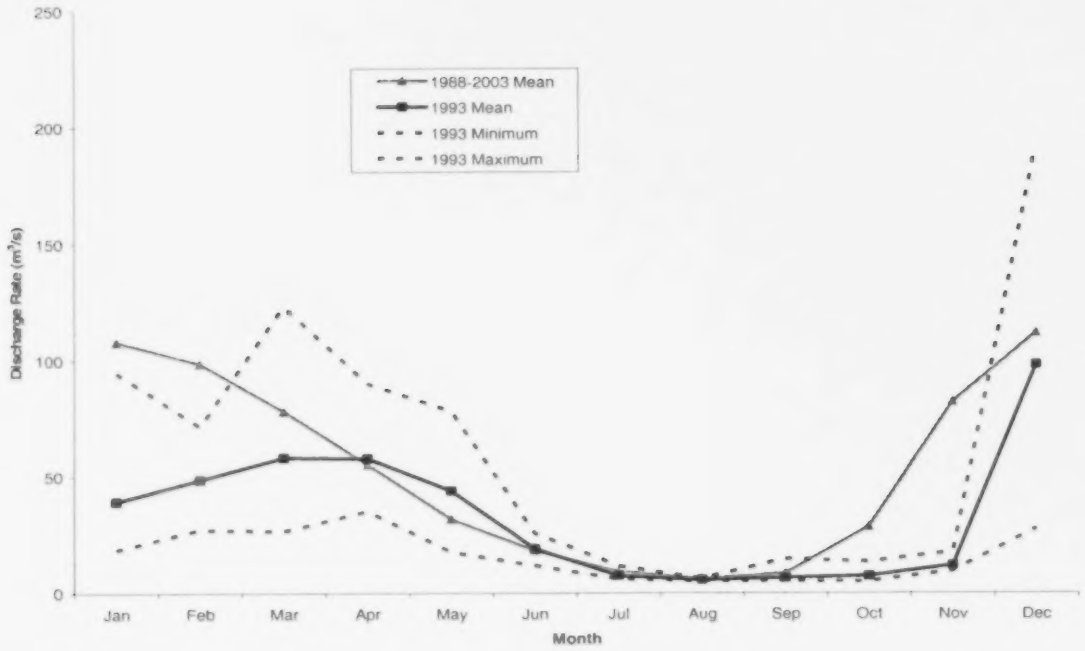


Figure 13. Monthly Cowichan River discharge (m^3/s) in 1993 along with period mean.

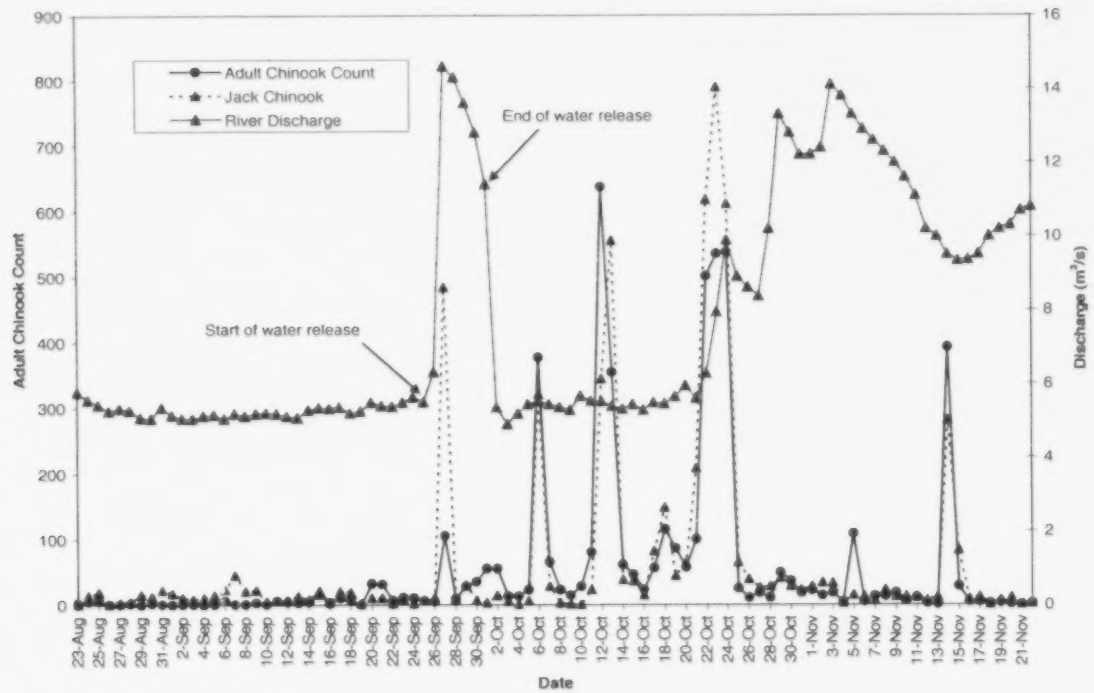


Figure 14. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1993.

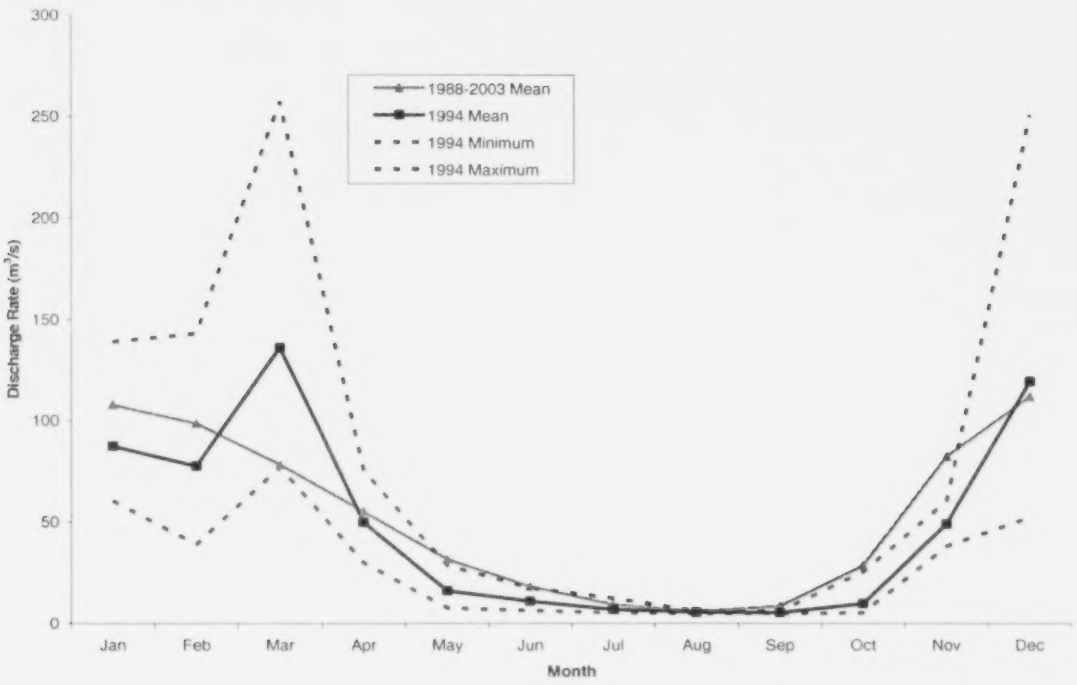


Figure 15. Monthly Cowichan River discharge (m^3/s) in 1994 along with period mean.

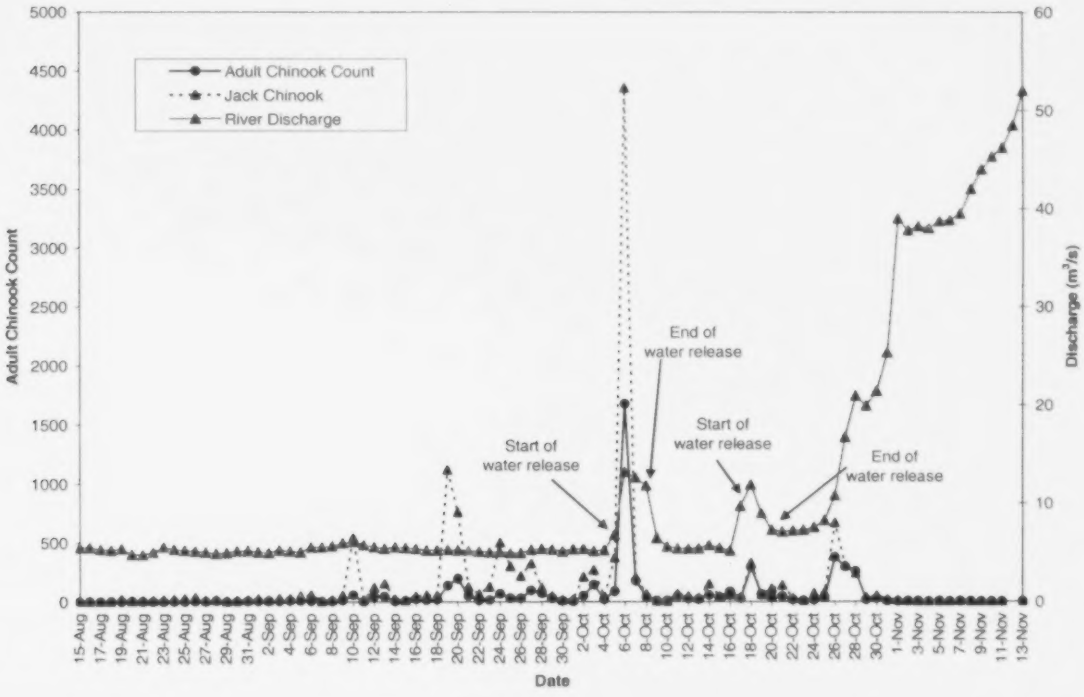


Figure 16. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1994.

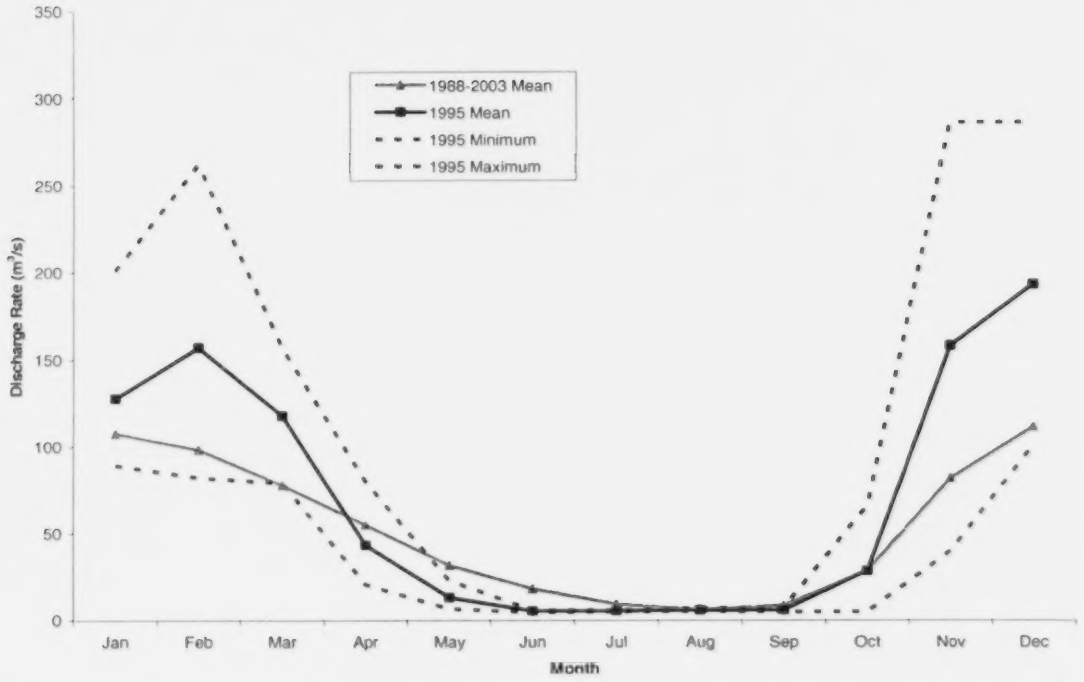


Figure 17. Monthly Cowichan River discharge (m^3/s) in 1995 along with period mean.

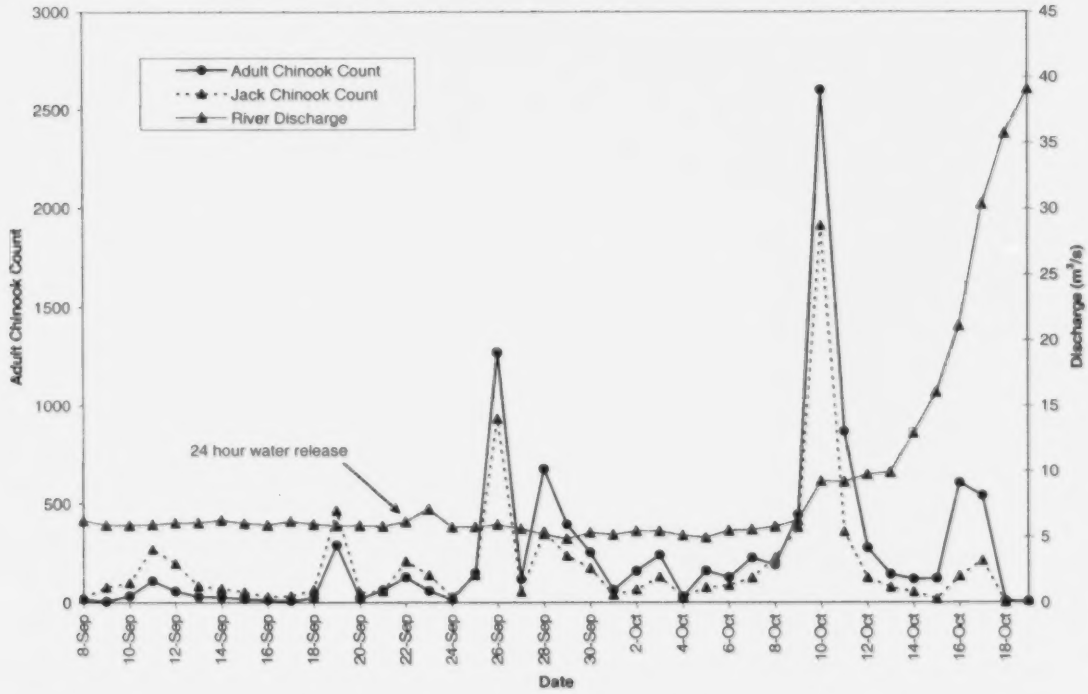


Figure 18. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1995.

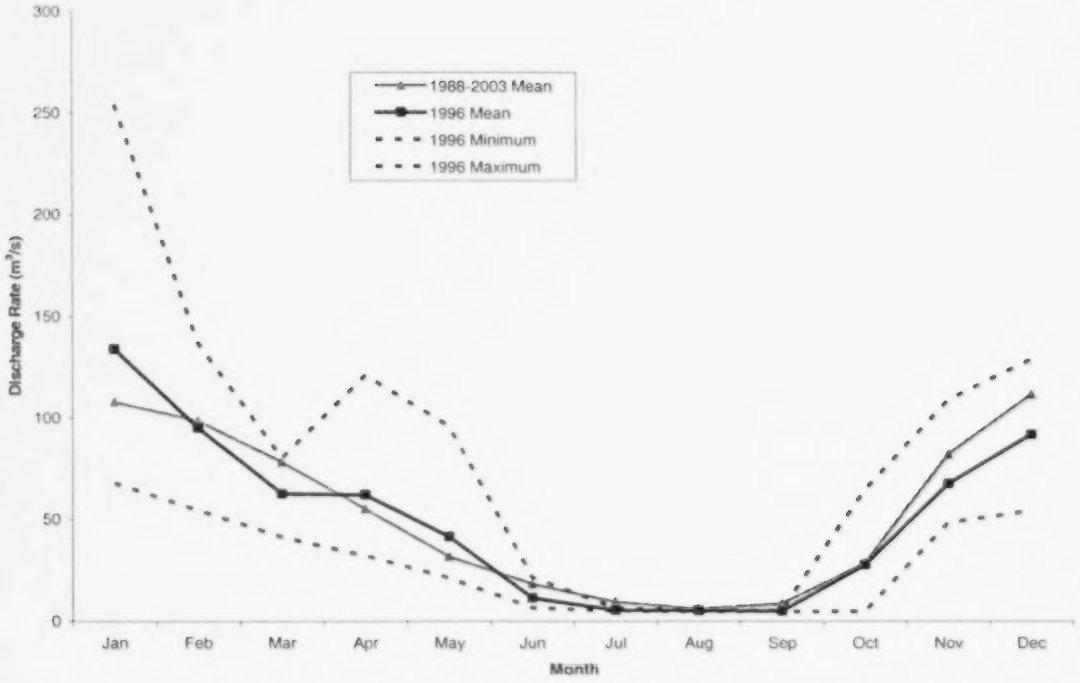


Figure 19. Monthly Cowichan River discharge (m^3/s) in 1996 along with period mean.

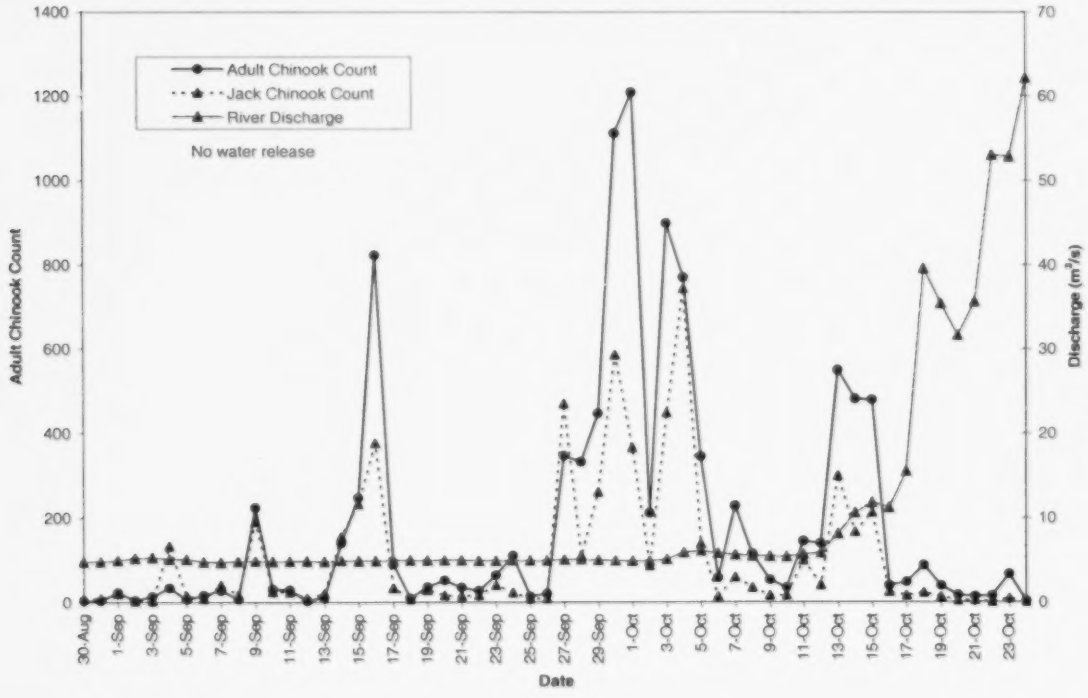


Figure 20. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1996.

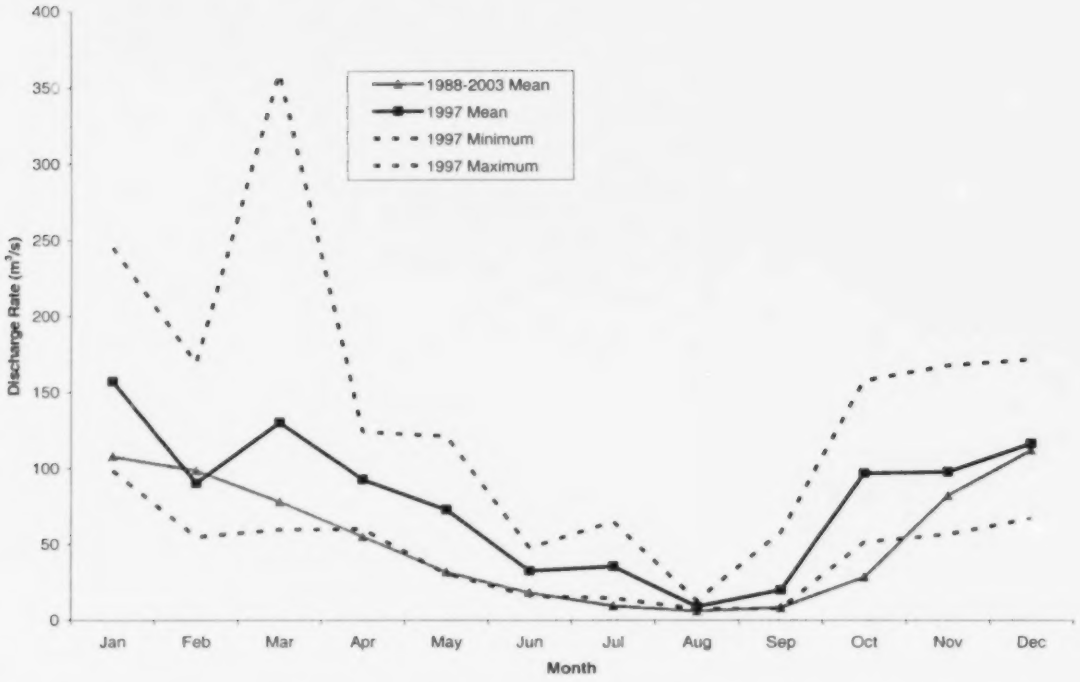


Figure 21. Monthly Cowichan River discharge (m^3/s) in 1997 along with period mean.

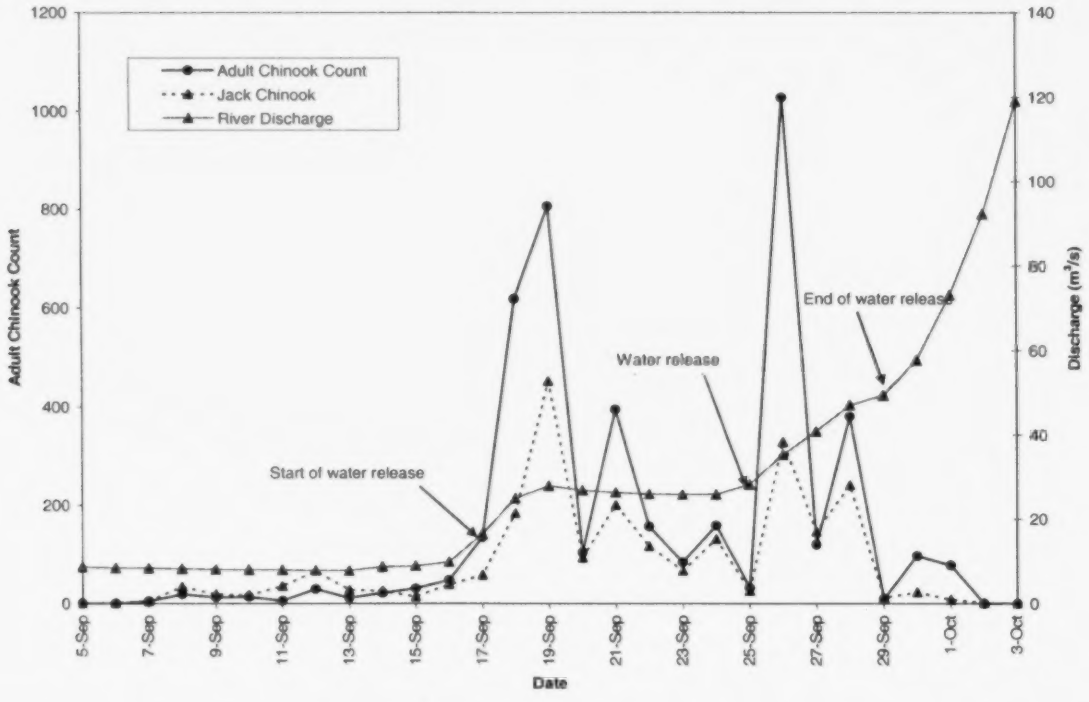


Figure 22. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1997.

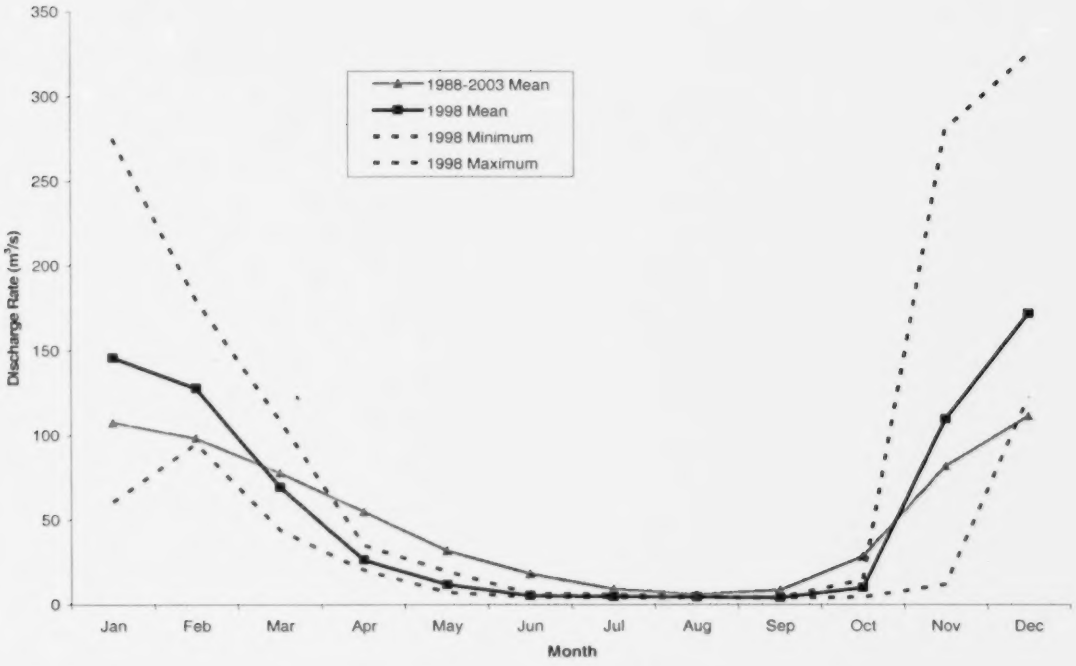


Figure 23. Monthly Cowichan River discharge (m^3/s) in 1998 along with period mean.

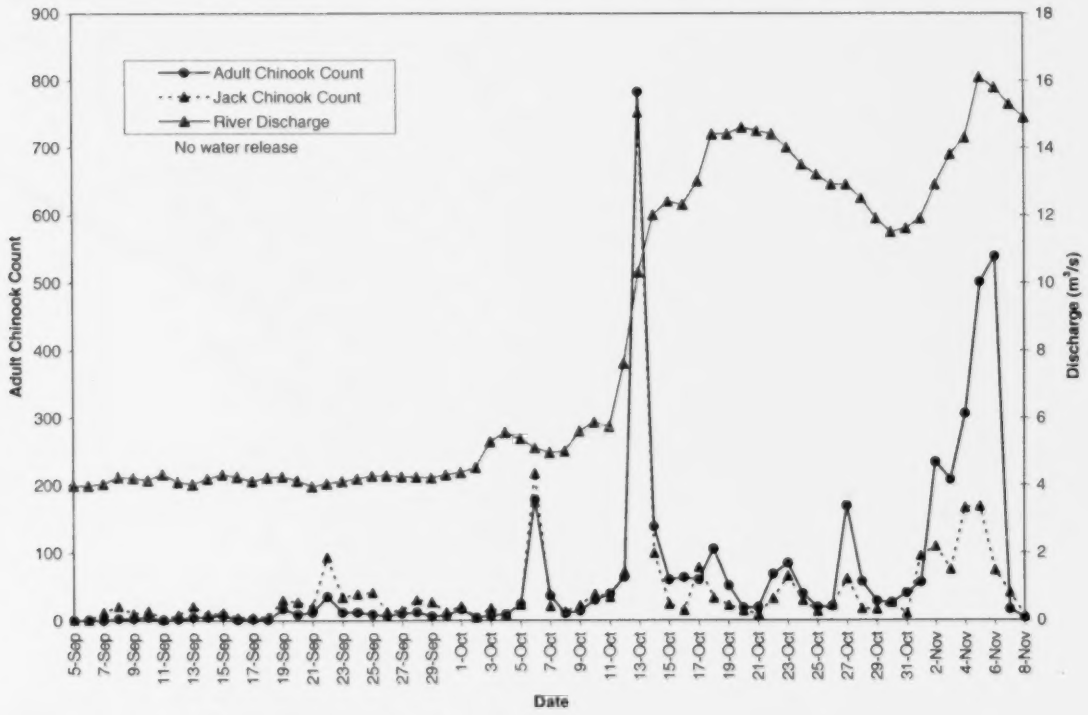


Figure 24. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1998.

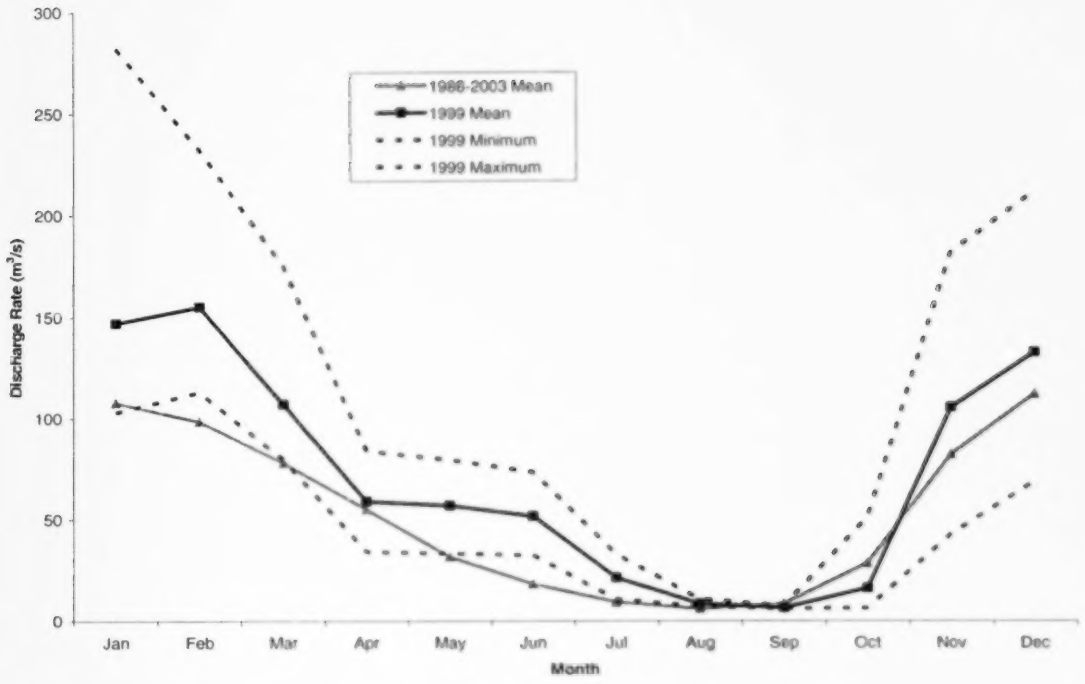


Figure 25. Monthly Cowichan River discharge (m^3/s) in 1999 along with period mean.

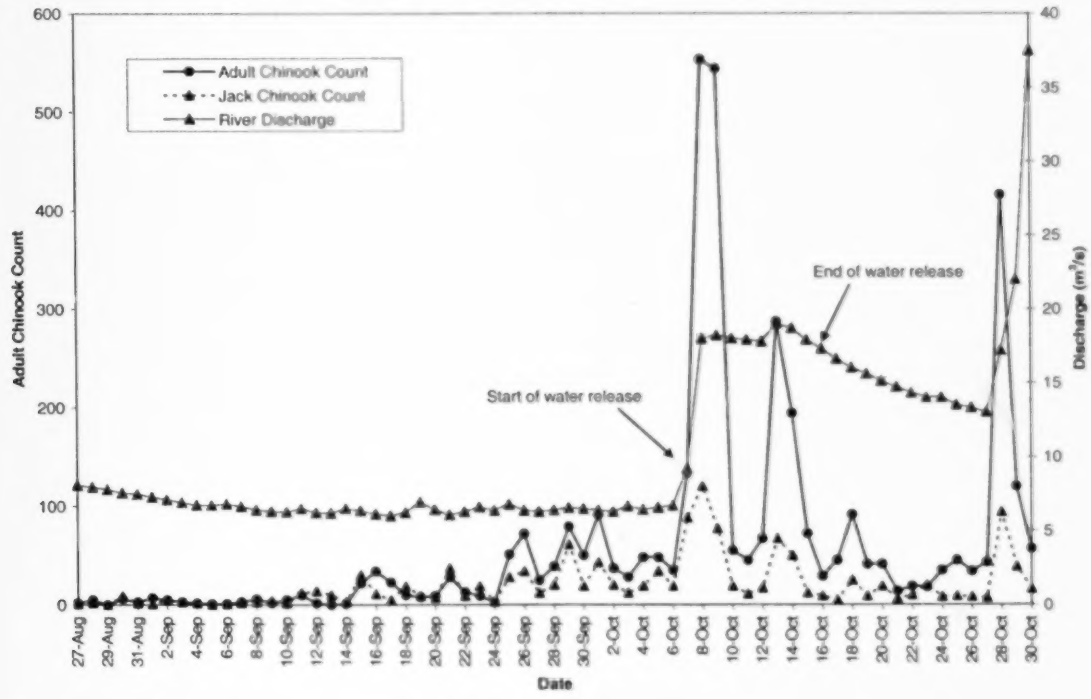


Figure 26. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 1999.

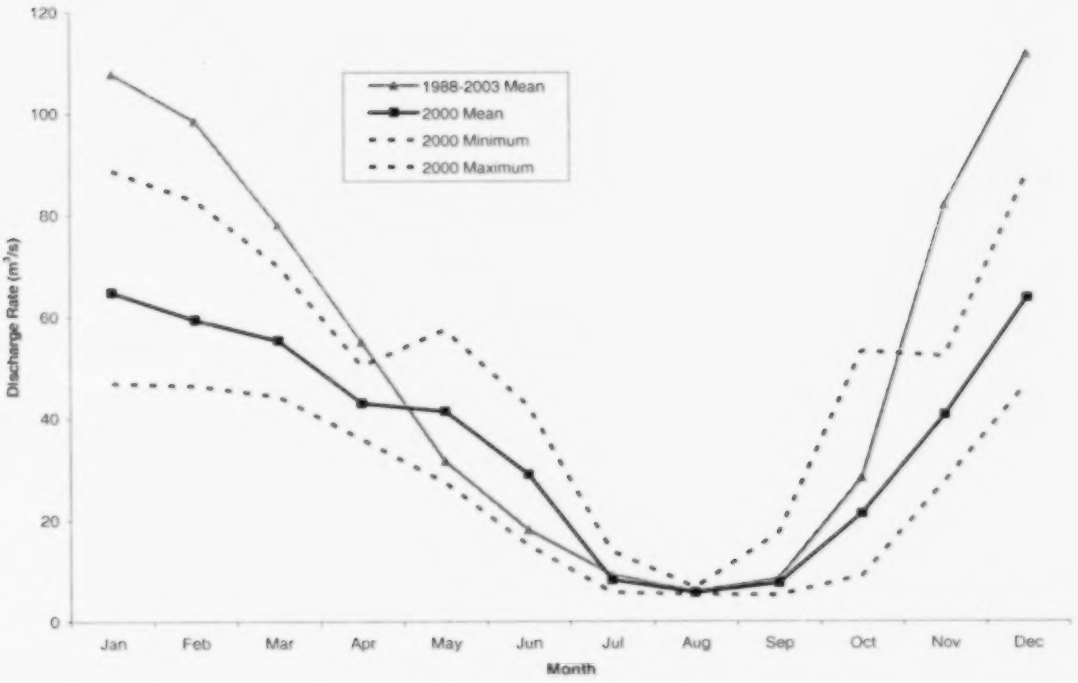


Figure 27. Monthly Cowichan River discharge (m^3/s) in 2000 along with period mean.

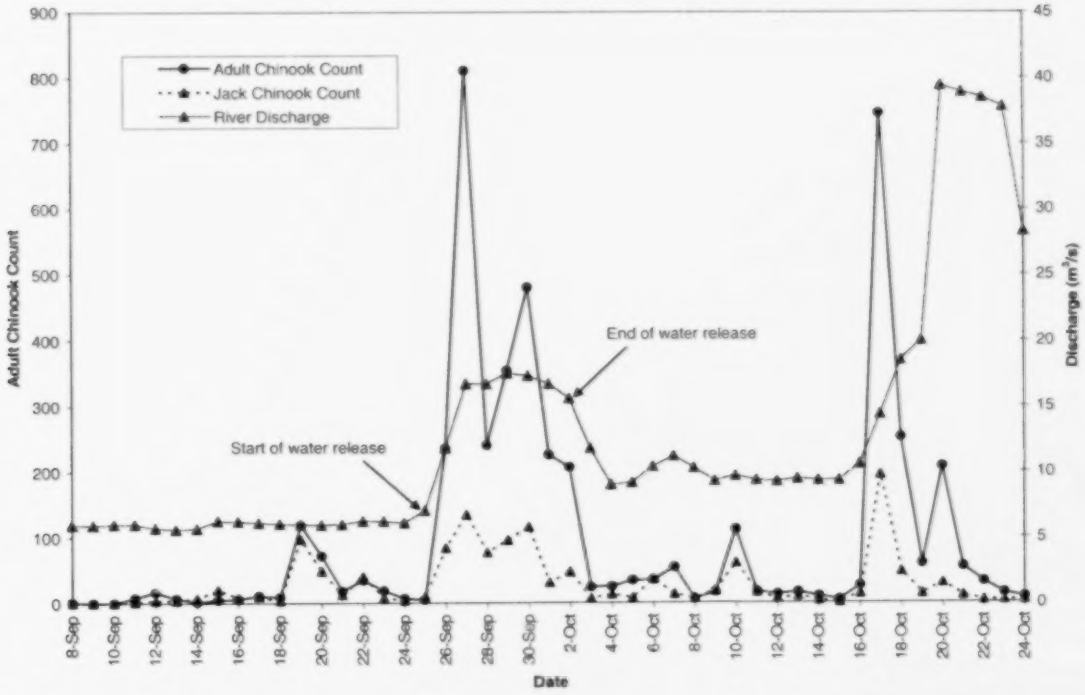


Figure 28. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 2000.

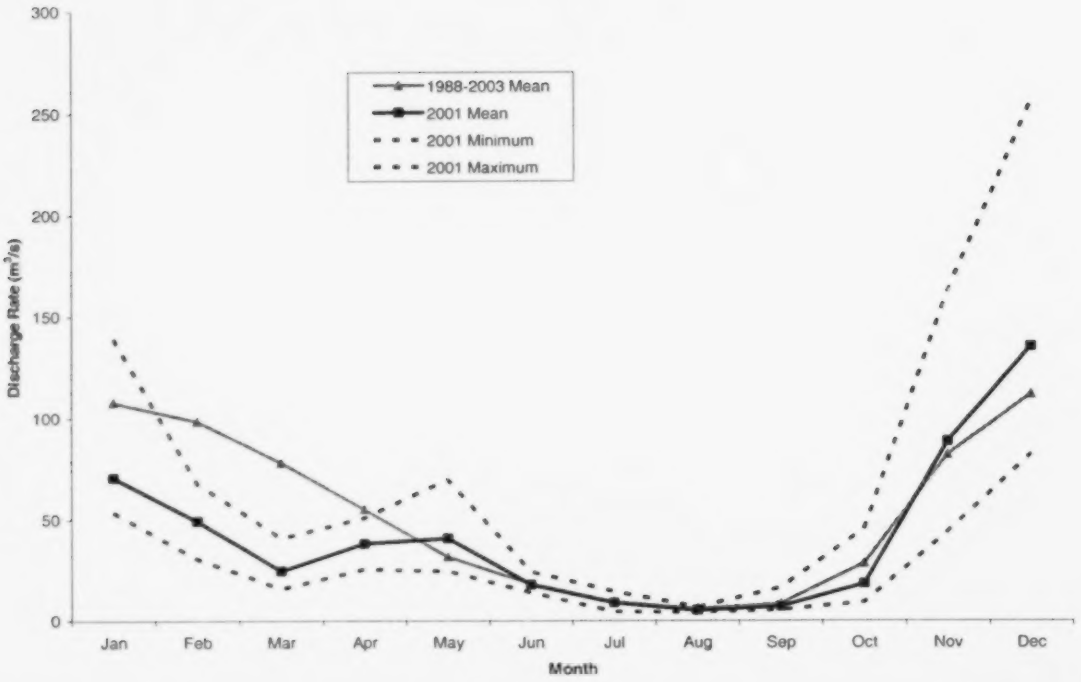


Figure 29. Monthly Cowichan River discharge (m^3/s) in 2001 along with period mean.

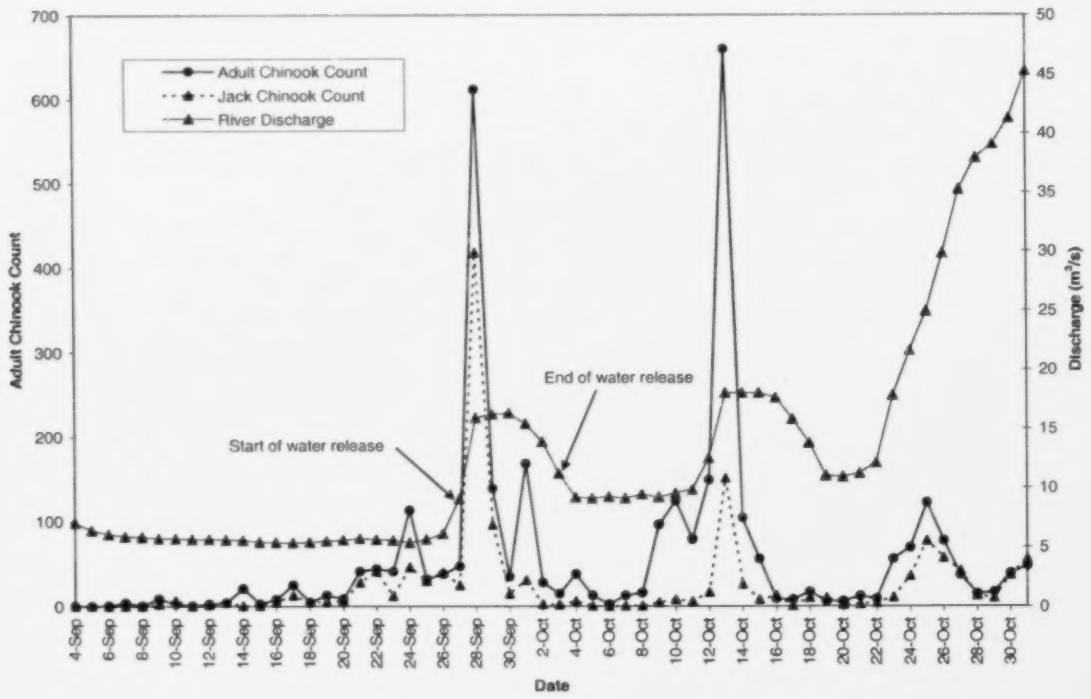


Figure 30. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 2001.

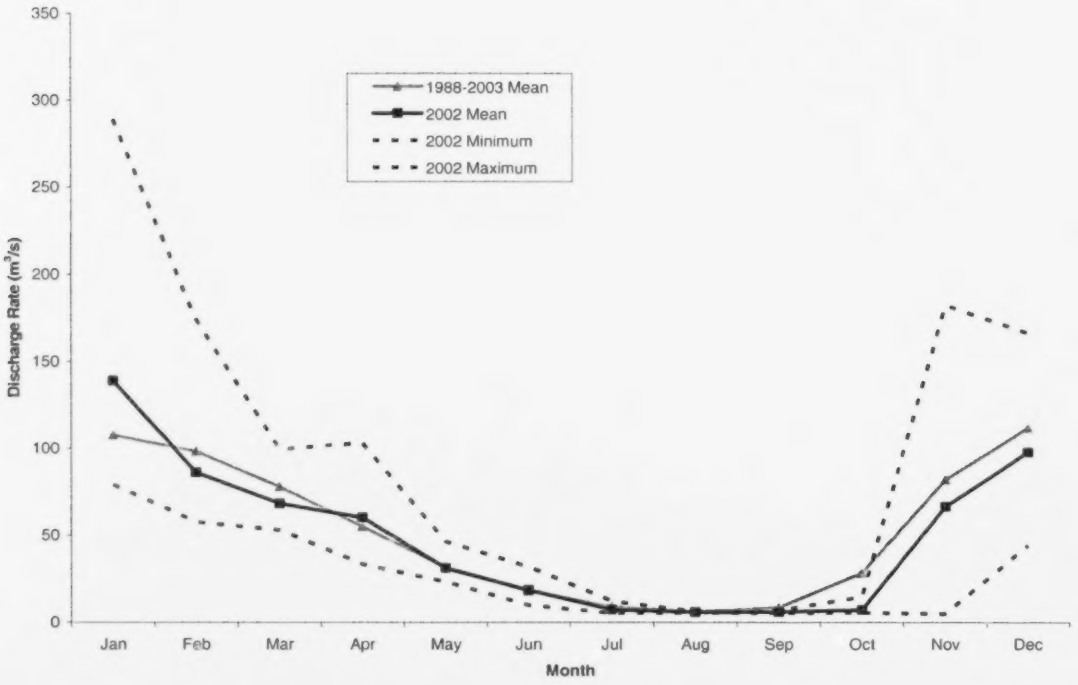


Figure 31. Monthly Cowichan River discharge (m^3/s) in 2002 along with period mean.

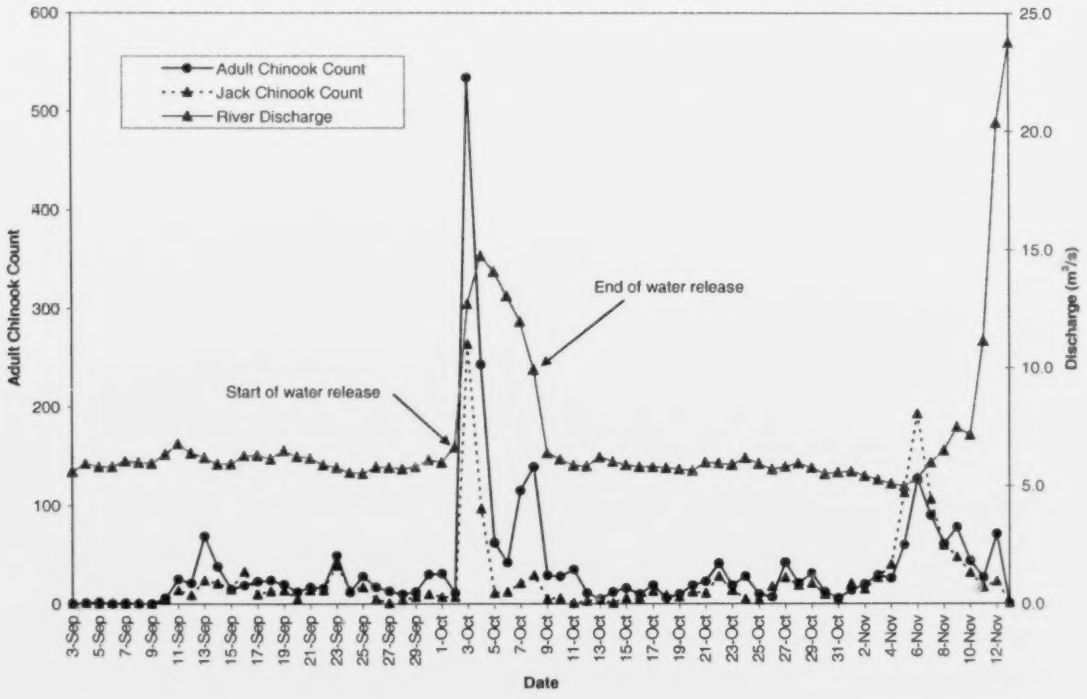


Figure 32. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 2002.

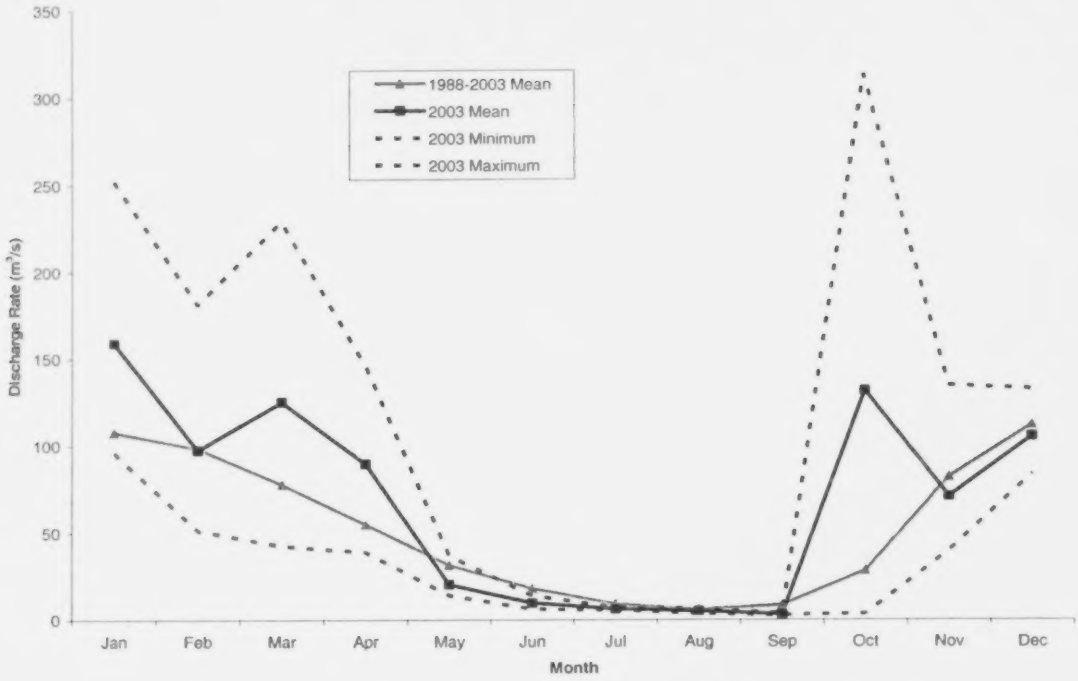


Figure 33. Monthly Cowichan River discharge (m^3/s) in 2003 along with period mean.

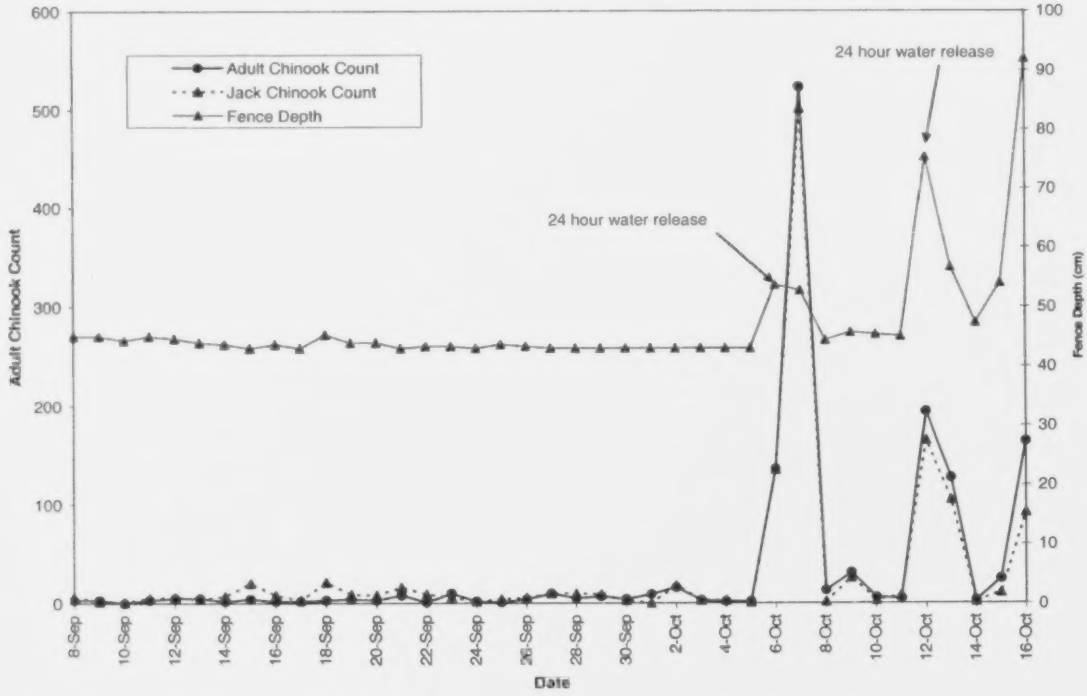


Figure 34. Daily river depth (cm) and chinook counts, Cowichan River, 2003.

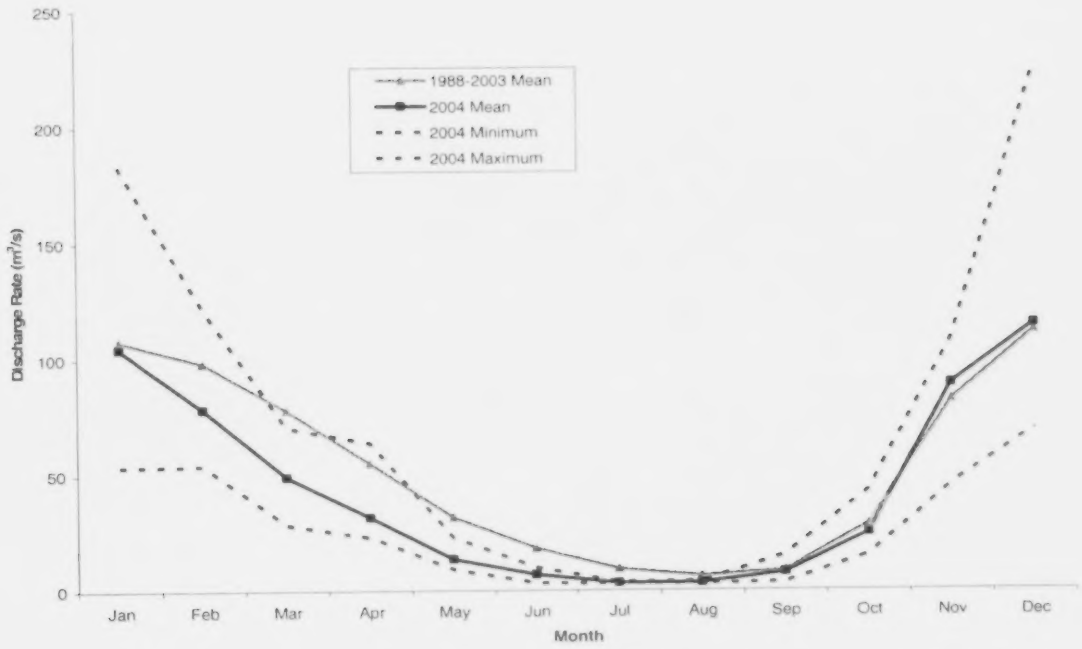


Figure 35. Monthly Cowichan River discharge (m^3/s) in 2004 along with period mean.

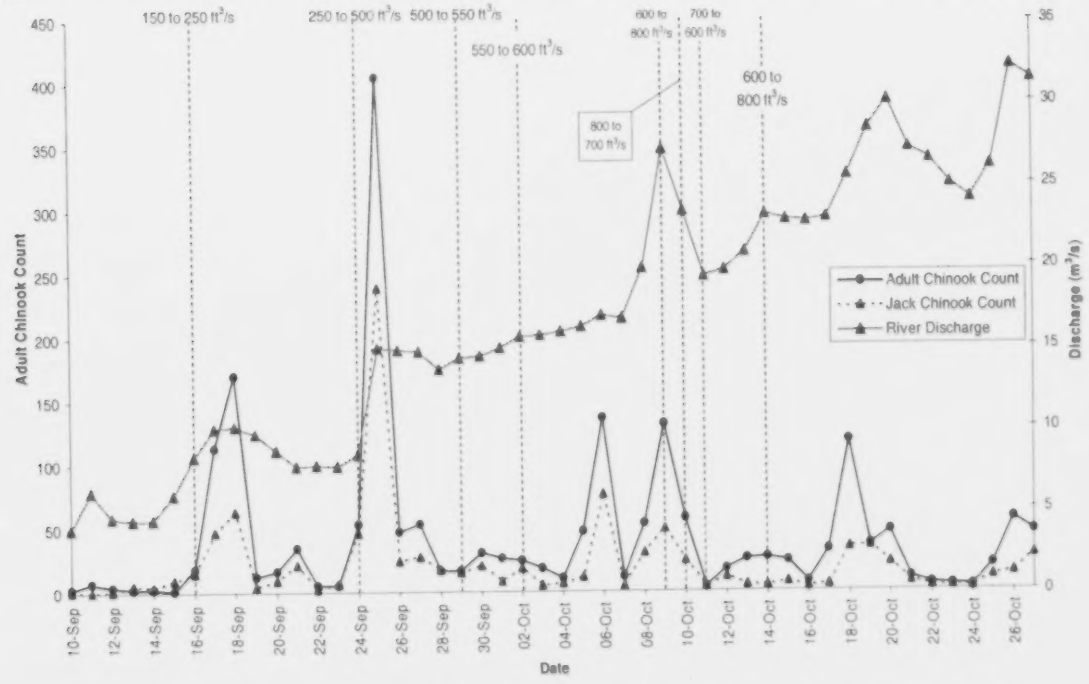


Figure 36. Daily discharge rate (m^3/s) and chinook counts, Cowichan River, 2004.
Discharge information is preliminary and subject to revision.

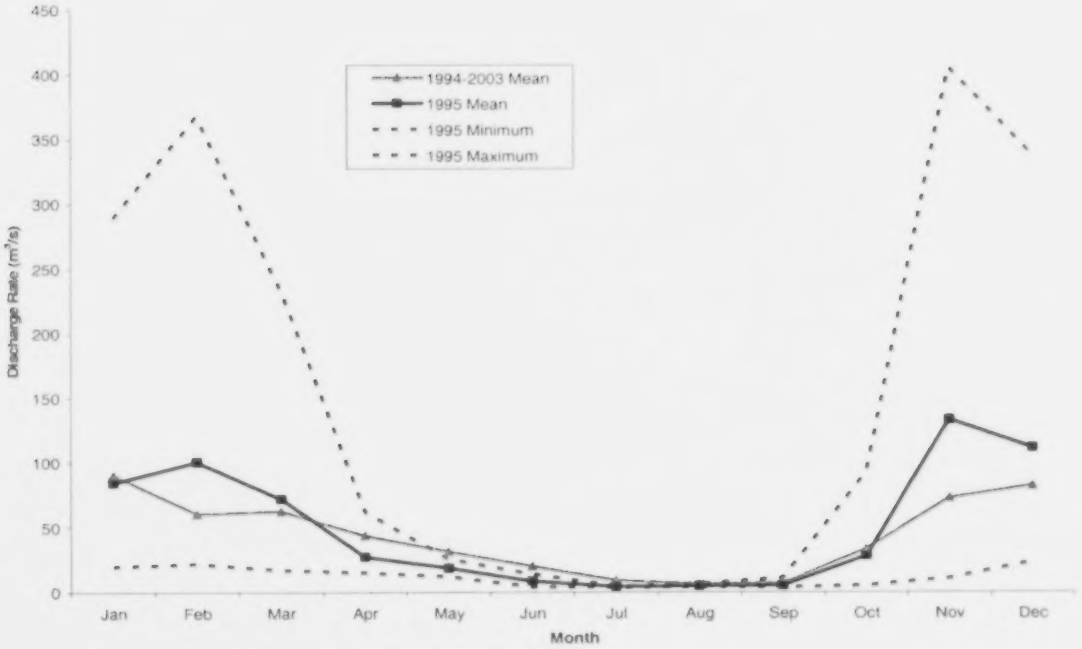


Figure 37. Monthly Nanaimo River discharge (m^3/s) in 1995 along with period mean.

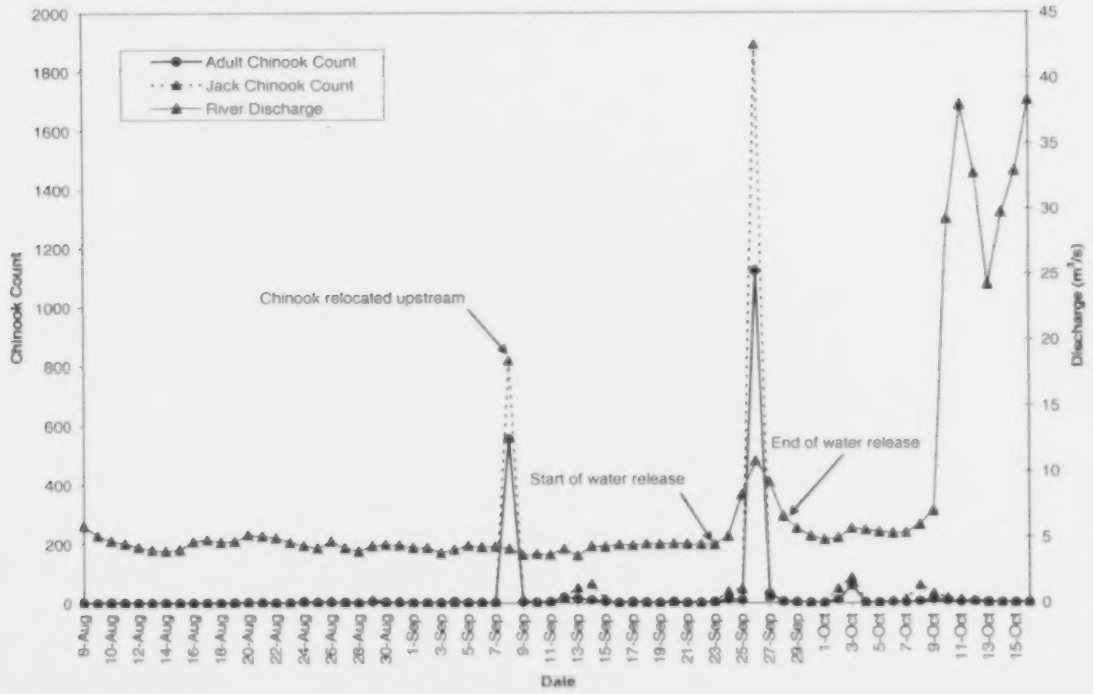


Figure 38. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1995.

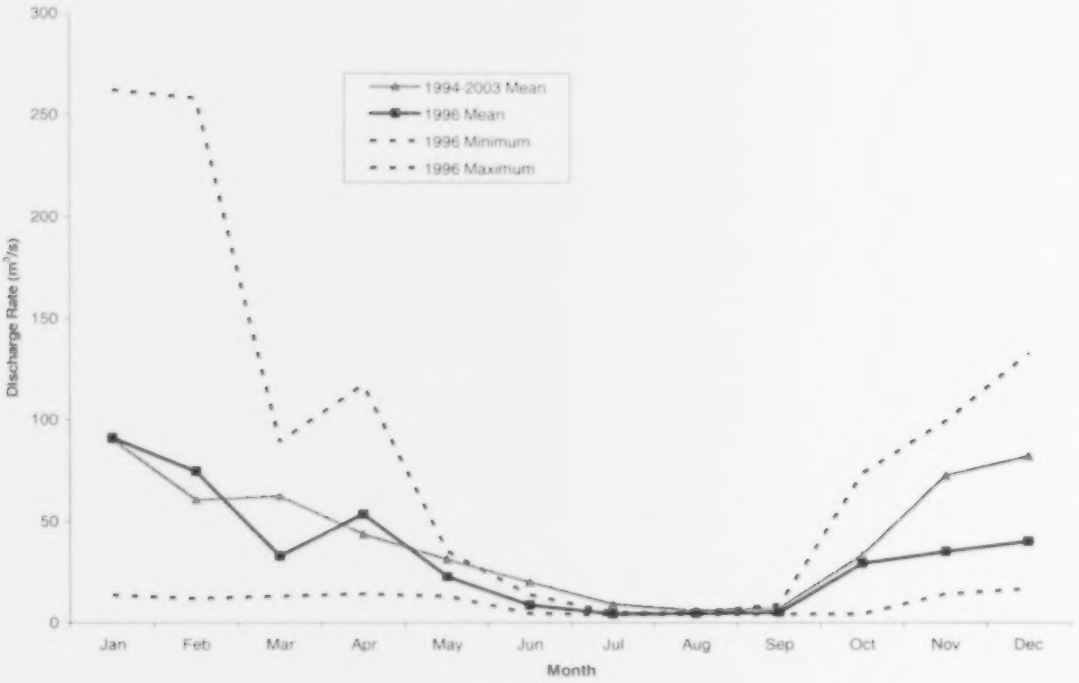


Figure 39. Monthly Nanaimo River discharge (m^3/s) in 1996 along with period mean.

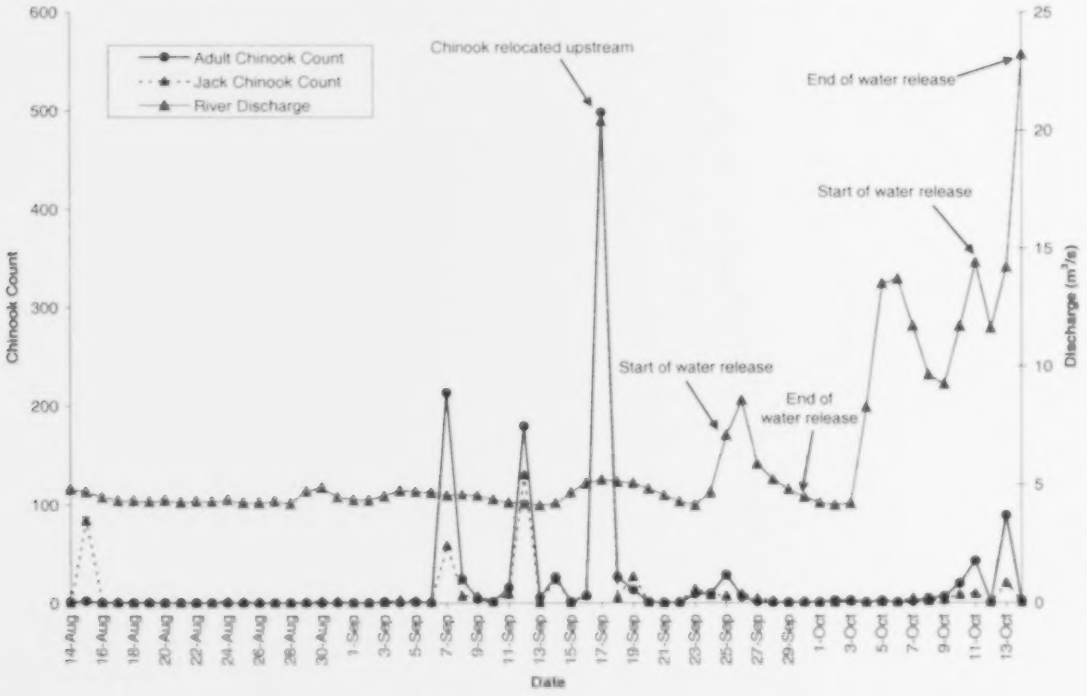


Figure 40. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1996.

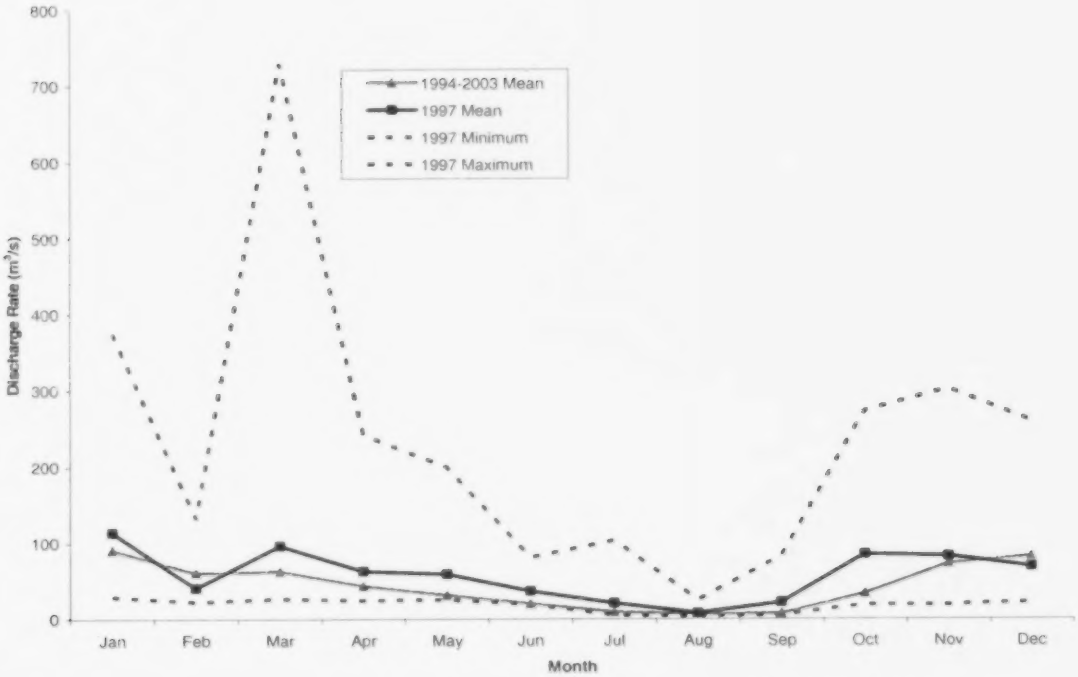


Figure 41. Monthly Nanaimo River discharge (m^3/s) in 1997 along with period mean.

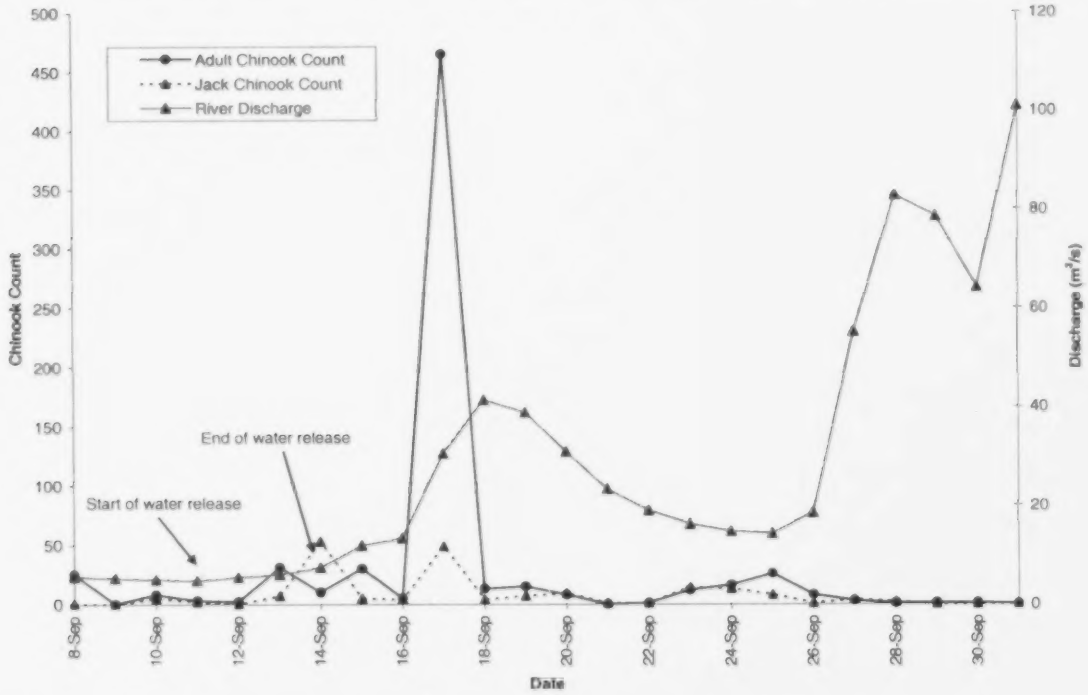


Figure 42. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1997.

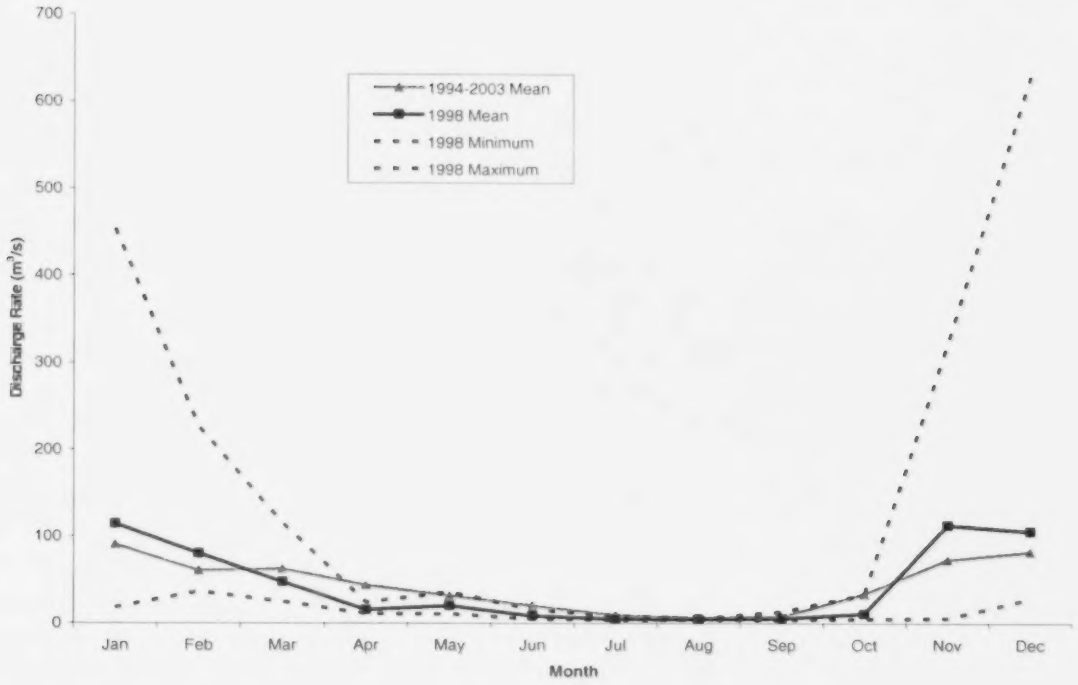


Figure 43. Monthly Nanaimo River discharge (m^3/s) in 1998 along with period mean.

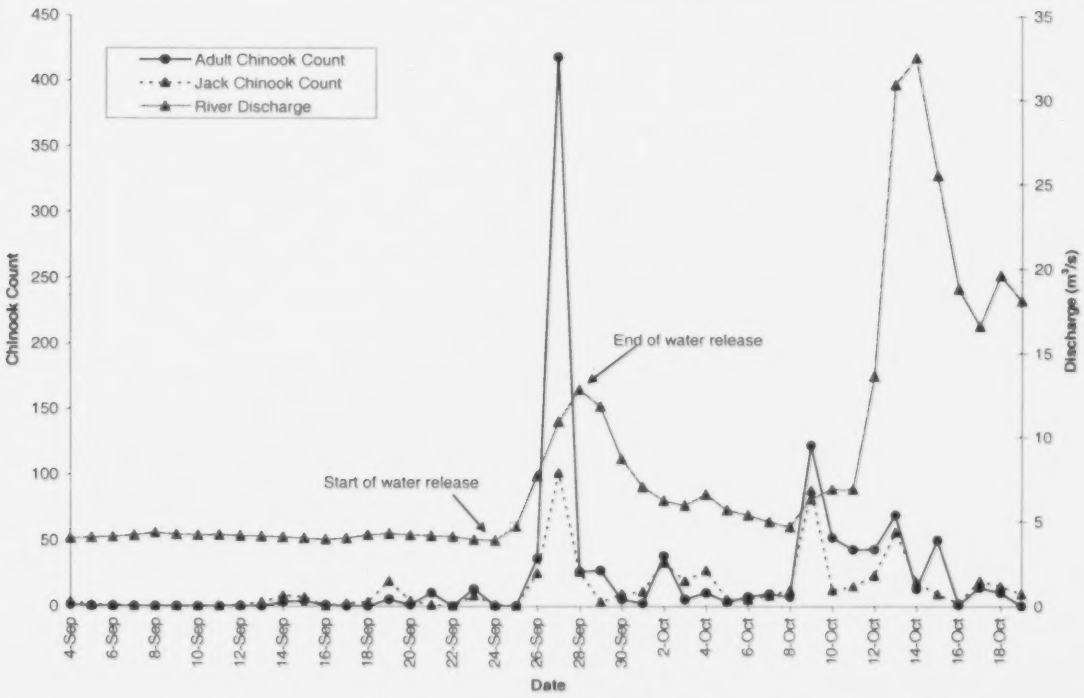


Figure 44. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1998.

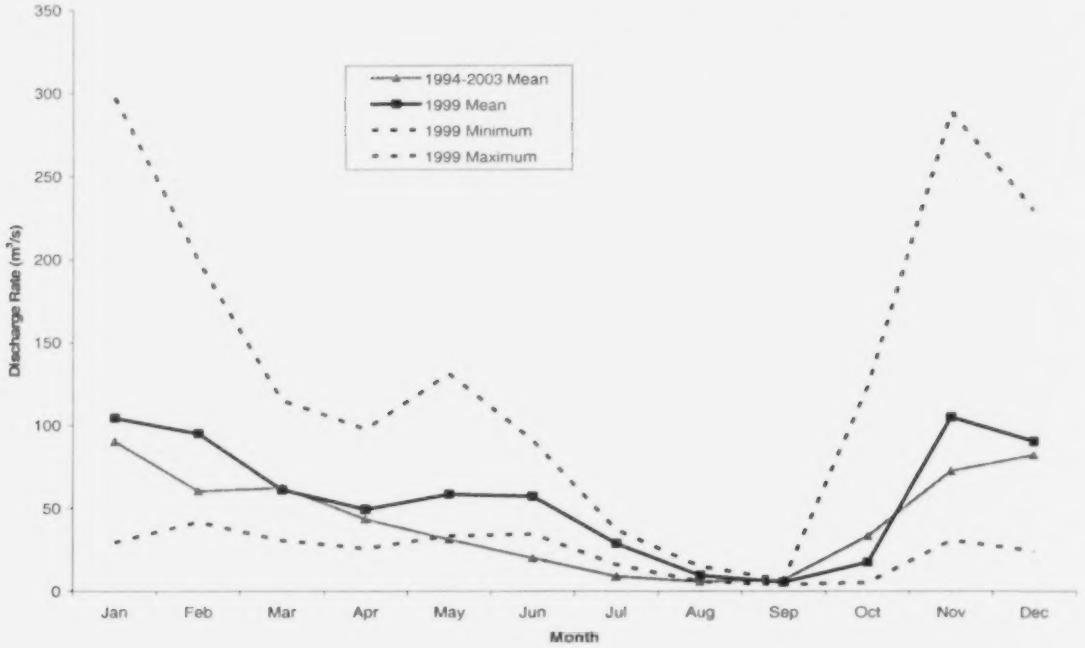


Figure 45. Monthly Nanaimo River discharge (m^3/s) in 1999 along with period mean.

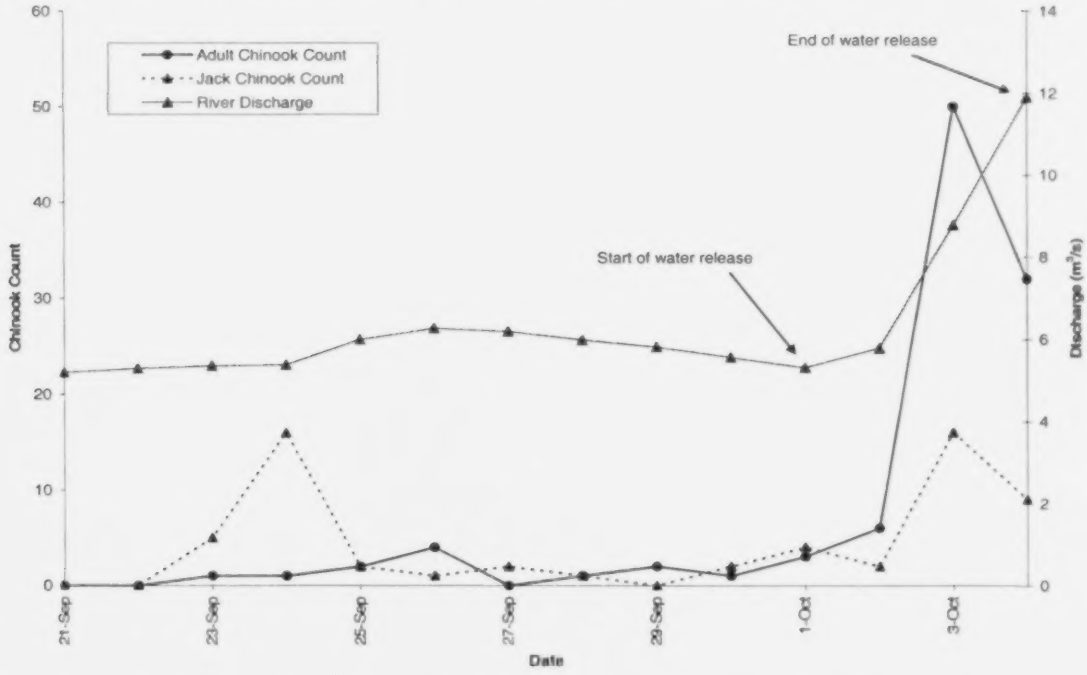


Figure 46. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 1999.

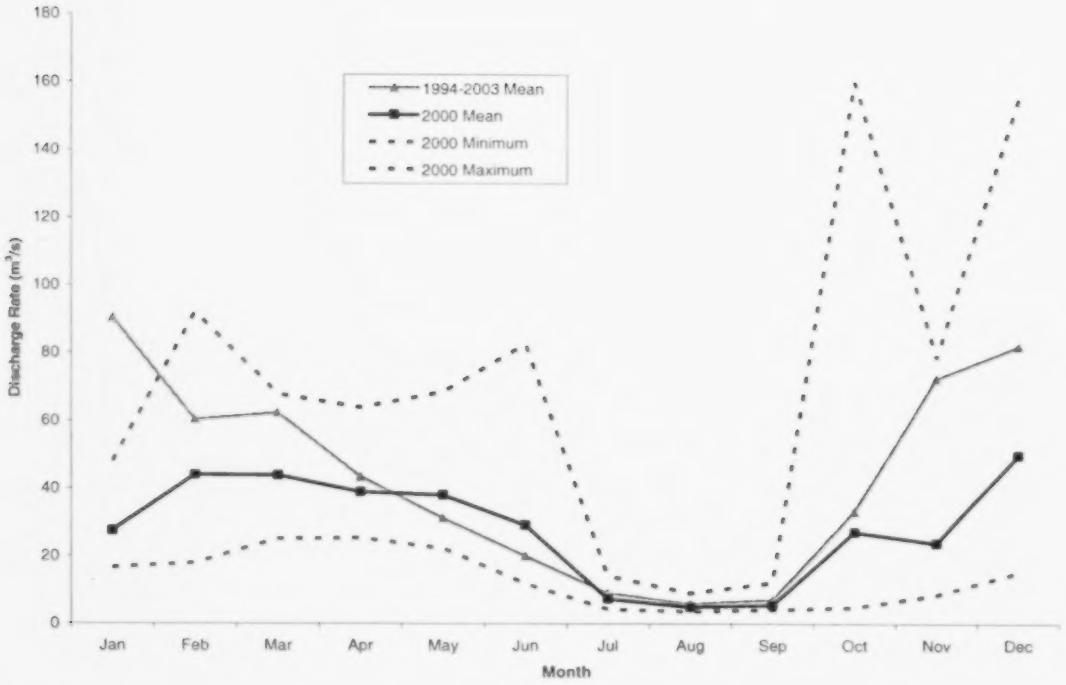


Figure 47. Monthly Nanaimo River discharge (m^3/s) in 2000 along with period mean.

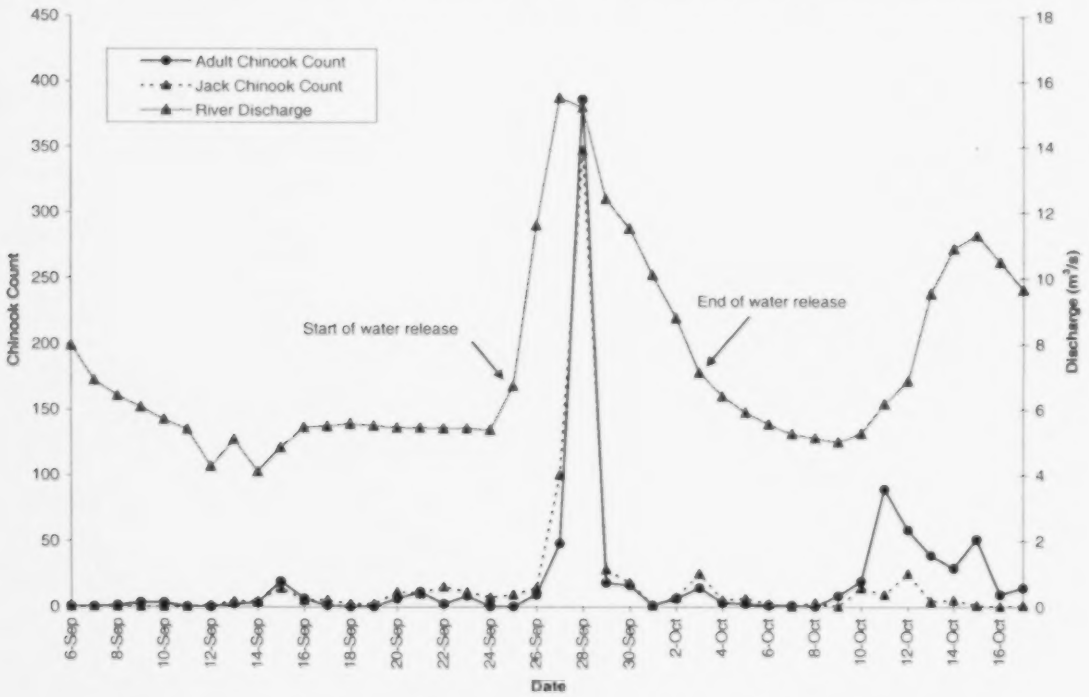


Figure 48. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 2000.

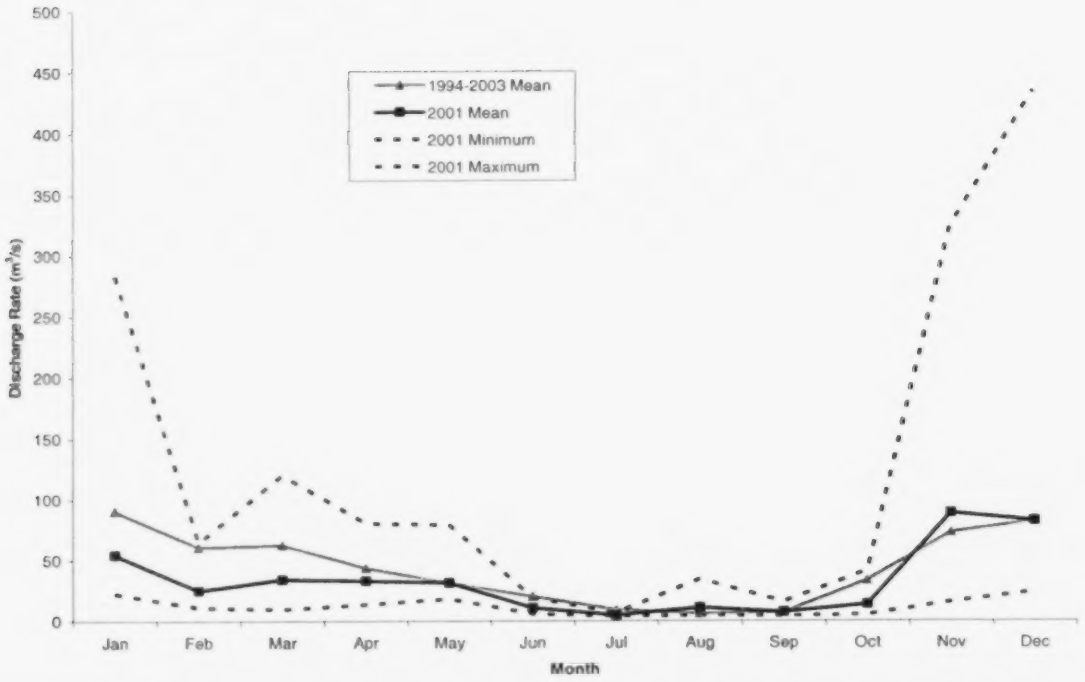


Figure 49. Monthly Nanaimo River discharge (m^3/s) in 2001 along with period mean.

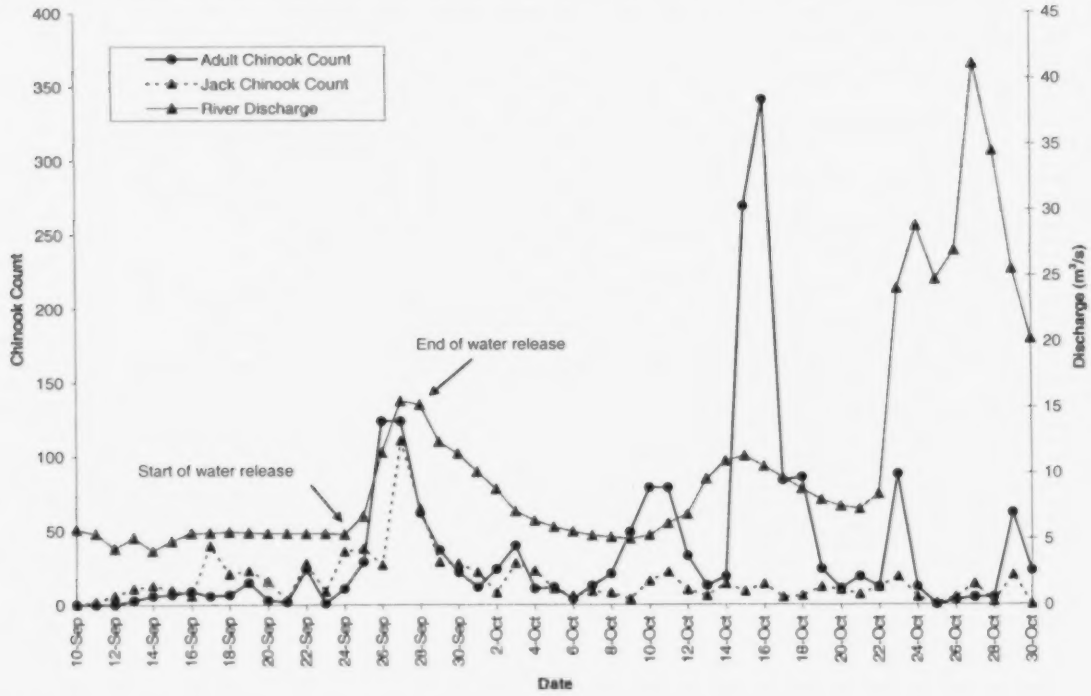


Figure 50. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 2001.

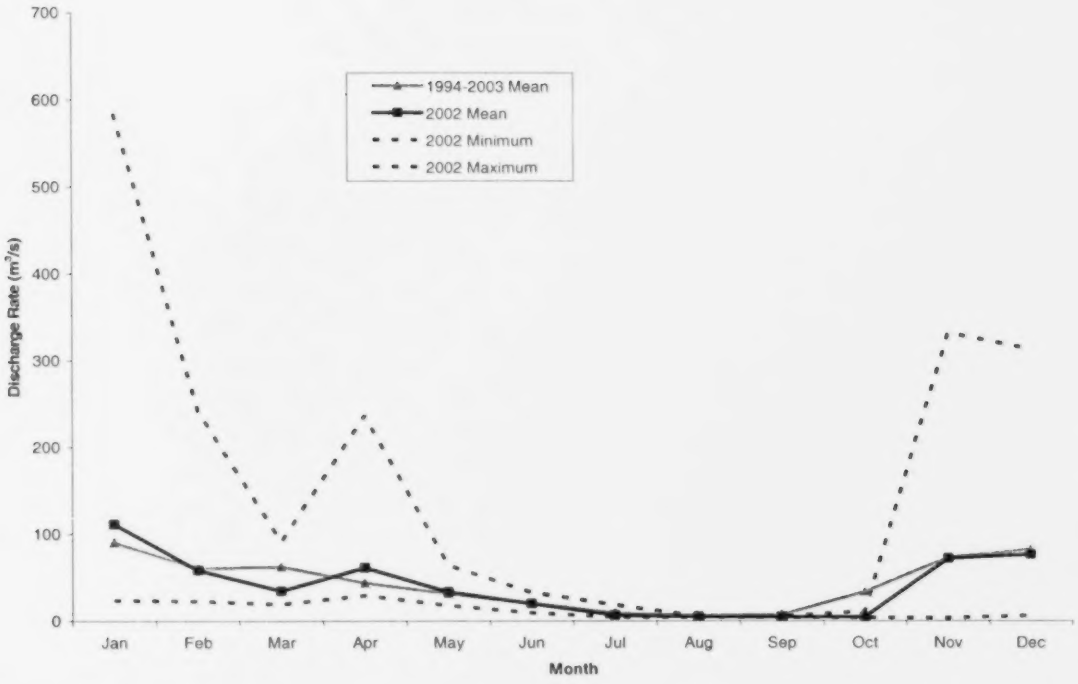


Figure 51. Monthly Nanaimo River discharge (m^3/s) in 2002 along with period mean.

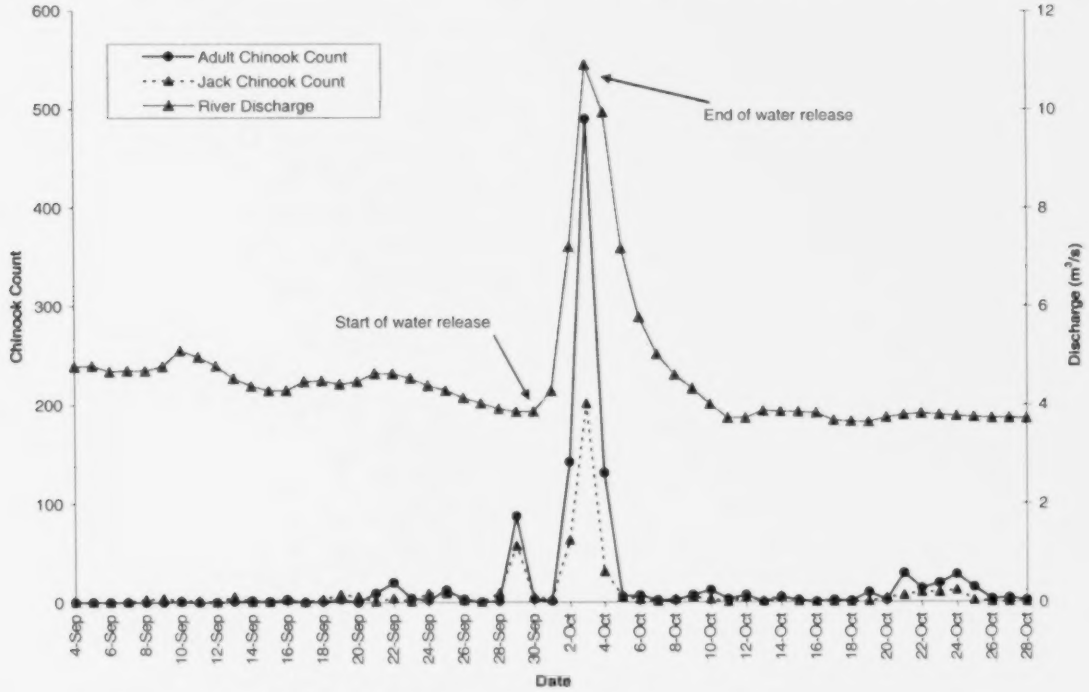


Figure 52. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 2002.

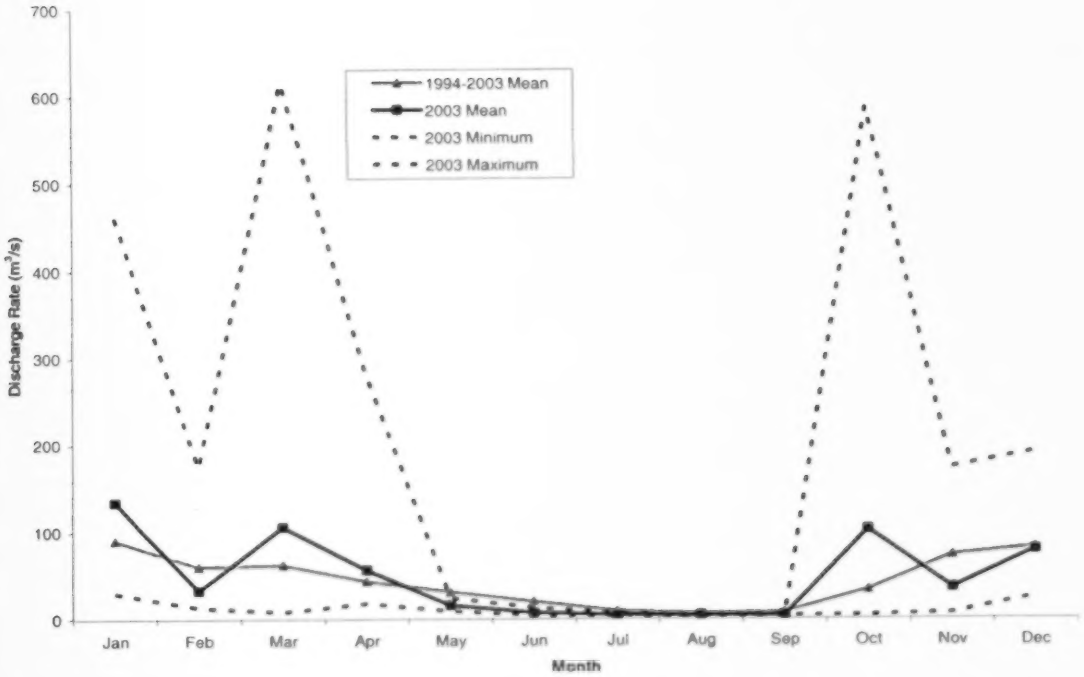


Figure 53. Monthly Nanaimo River discharge (m^3/s) in 2003 along with period mean.

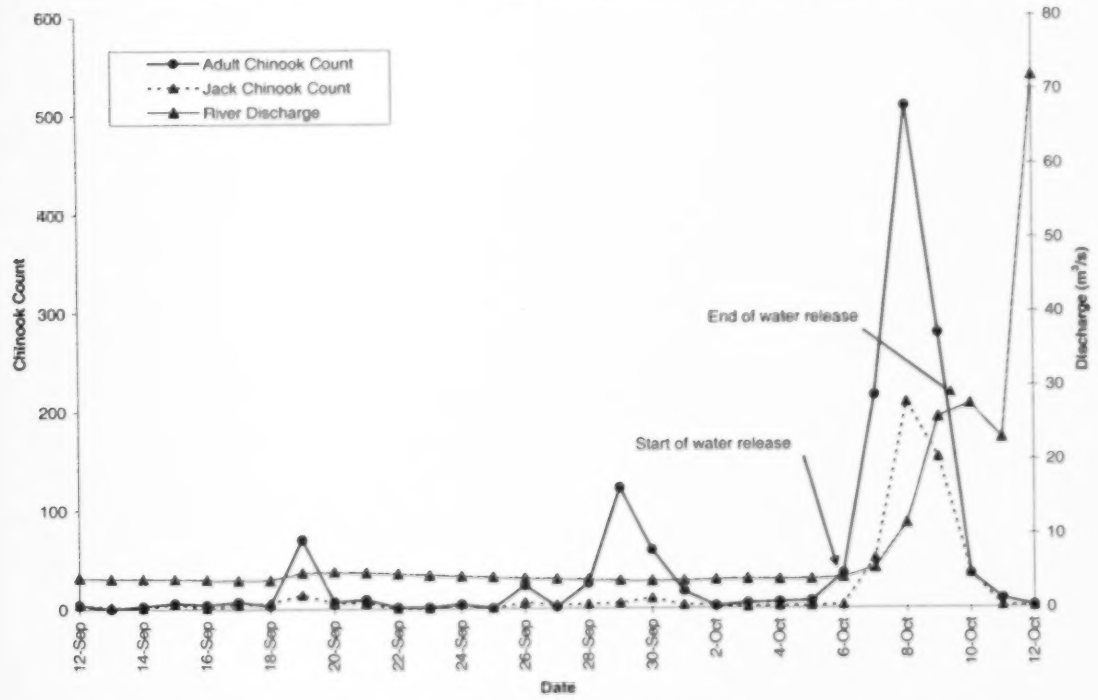


Figure 54. Daily discharge rate (m^3/s) and chinook counts, Nanaimo River, 2003.

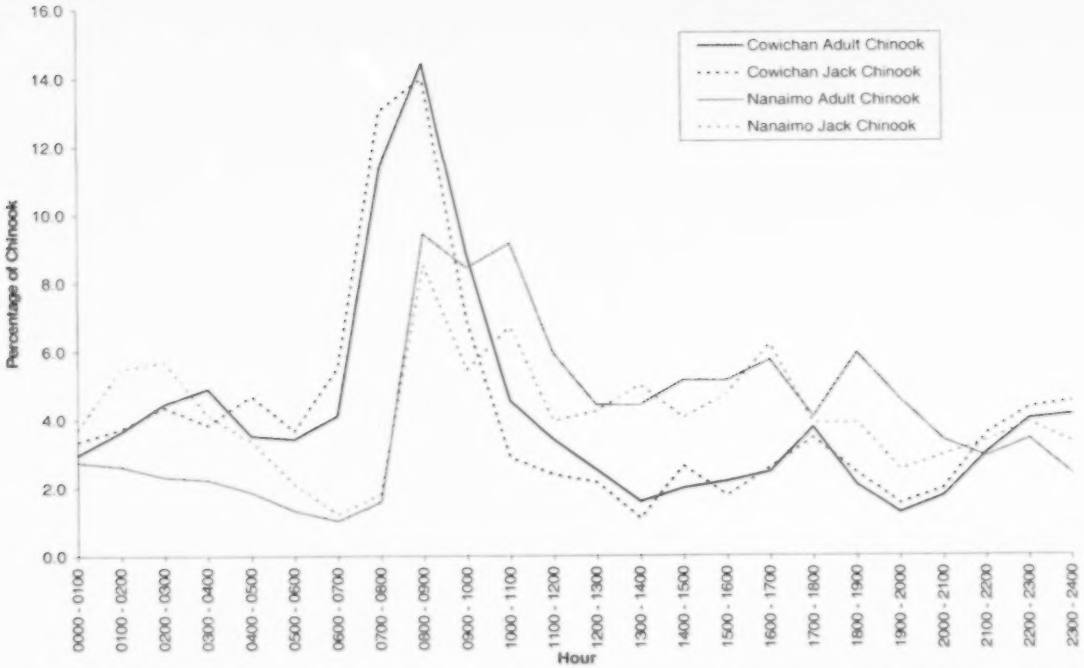


Figure 55. Mean total counts by time interval at the Cowichan River (2000-2004) and Nanaimo River (2000-2003) enumeration fences.